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VOLUME 33 NOVEMBER, 1959 NUMBER 6

ADOLESCENT CEPHALOPODS FROM THE EXSHAW FORMATION OF ALBERTA

OTTO H. SCHINDEWOLF
University of Tübingen, Germany

ABSTRACT—A collection of nepionic goniatites exhibits three different types of sutural development. Their representatives can be connected with the genera *Imitoceras*, *Protocanites*, and an undetermined genus possibly related to *Prodromites*. The Lower Mississippian age of the Exshaw formation may thus be confirmed.

INTRODUCTION

BY THE good offices of one of my former students, Dr. G. Westermann, now at Hamilton College, McMaster University, Hamilton, Ontario, I received a remarkable pyritized microfauna from the Exshaw formation near the Brazeau River, Jasper Park, Alberta. The horizon and locality are the same as indicated by C. B. Pamenter in his short note on *Imitoceras* from the Exshaw formation (1956).

The material is in the possession partly of the Hamilton College, Department of Geology, and partly of the Shell Oil Company of Canada, Ltd., Calgary. The latter kindly gave permission for publication of the following report. My friend, Dr. W. M. Furnish was good enough to read the manuscript. To all these individuals I render my sincerest thanks for their valuable support.

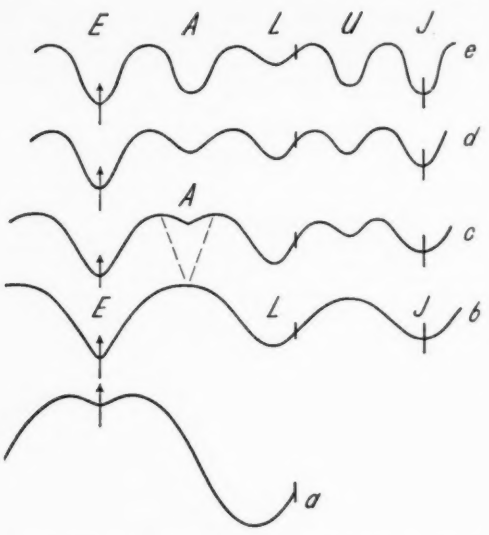
The faunule is exceptionally well preserved. It consists, besides some ostracodes, young gastropods, and very small pelecypods, mainly of early adolescent stages of cephalopods. Of special interest are about 45 protoconchs of goniatites with adherent parts of the first volution or whorls, mostly fragments of larger individuals. Their description is the main purpose of this paper, whereas the straight cylindrical cephalopods with similarly preserved protoconchs are treated more cursorily.

COILED GONIATITES

Among the juvenile coils three different types are to be distinguished:

1. By far the majority of specimens (41) is characterized by a development of suture line which is represented in Text-figure 1. The prosuture belonging to the septum closing the protoconch is latisellate with a shallow depression at the top of the broad ventral saddle (Text-fig. 1a; Pl. 120, figs. 1–3). The primary suture (1b) contains the three lobes typical for all the primitive coiled goniatites and for the adolescent suture lines of the more advanced goniatites. The ventral or external lobe *E* and the dorsal or internal lobe *I* are situated in the median plane of the conch. Between them, near to the umbilical seam, there is a deeply rounded lobe which corresponds to the primary lateral lobe *L*.

In the next-following suture line (1c) the broad saddle between *E* and *L* is subdivided by the first minute indentation of an ad-



TEXT-FIG. *1*—Ontogenetic development of suture line in *Imitoceras* sp., based on several specimens from the Exshaw formation; *a*, prosuture; *b*, primary suture; and *c–e*, later stages.

ventitious lobe *A* which very quickly increases in size (Pl. 120, figs. 4–6). At the same time the saddle between *L* and *I* is split by the insertion of an umbilical lobe *U* (Pl. 120, figs. 7,8). The lateral lobe *L* retains its original position near the umbilicus; in later stages it relatively decreases in depth and is surpassed by the strongly growing adventitious lobe occupying the middle of the whorl side. These are the characteristics of a modus which I have called "A-type" in the development of suture lines (Schindewolf, 1954a, b).

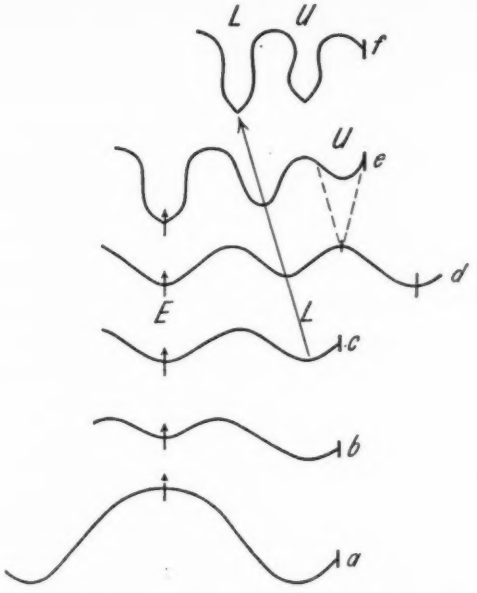
The sutural development of this Exshaw form agrees in every detail with that of an *Imitoceras* sp. from the lowermost Mississippian of Thuringia (Schindewolf, 1951). In both cases the adventitious lobe *A* is inserted in the second suture line, following the primary suture; the location and shape of all the lobes and saddles are absolutely the same. It therefore may be supposed that these adolescent stages of goniatites belong to the genus *Imitoceras* Schdwf.

Pamenter (1956) has proved the existence of *Imitoceras* in the Exshaw formation. I have examined his type and several other specimens, which possibly represent two species. One of the forms is characterized by a relatively broad, bell-shaped adventitious lobe and fine ribbing (Pl. 120, fig. 10). In the other, the corresponding lobe is narrower and the ribbing more conspicuous (Pl. 120, fig. 11). The former seems to be near to *Imitoceras discoidale* (Smith) as determined by A. K. Miller & W. M. Furnish (Pamenter, 1956). The small size and inadequate preservation do not allow an exact specific determination. The ribbing of this, or more probably of the other species, makes its appearance in very early stages of development. In one specimen (Pl. 120, fig. 9) ribs are already perceptible at a diameter of 1.5 mm. (one and a half volutions). Here the ribs are nearly straight, fine, and densely crowded.

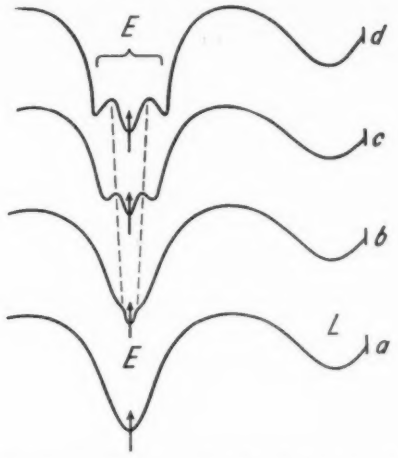
All the early growth stages are remarkably constant as far as the general type of development: the small indenture in the external saddle of the prosuture, the appearance of the adventitious lobe in the second suture line, the extreme ventral position of the siphuncle, etc. Only the depth of the adventitious lobe in the stage of its anlage is slightly variable, ranging from a very shallow indentation to a somewhat deeper concavity. Again, in one specimen it was observed that the lobe *L* is narrowly rounded or nearly pointed at its base. This variation is true only for the one side of the whorl, for on the other side it shows the normal broadly rounded base. Otherwise, the 41 specimens are identical in every respect.

2. A second type of sutural development is represented by one specimen only (Pl. 121, fig. 6). The prosuture (Text-fig. 2a) is latisellate as in the former case, but it differs by the broadly rounded undepressed top of the saddle. The primary suture (Text-fig. 2b) exhibits in its external part two broadly rounded lobes *E* and *L*, separated by a low broad saddle.

The further development of the suture line is characterized by the fact that the last-mentioned saddle is not subdivided; no adventitious lobe is formed, as was the case in the former instance. The lateral lobe, originally situated near the umbilical seam is gradually shifted to the middle of the whorl side; it is, and remains, immediately adjacent to *E*. New elements, umbilical



TEXT-FIG. 2—Ontogenetic development of suture line in *Protocanites* cf. *P. gurleyi* (Smith), based on several specimens from the Exshaw formation: *a*, prosuture; *b*, primary suture; *c*, *d*, later stages; *e*, from the specimen figured in Pl. 121, fig. 5; and *f* from a specimen at the Crowsnest Coal Company mine, Fernie, B. C., found in the Exshaw formation near Fernie.



TEXT-FIG. 3—Ontogenetic development of the external suture in genus indeterminate related to *Prodromites;* based on two specimens from the Exshaw formation, figured in Pl. 121, fig. 3b, 4.

lobes, originate only at the dorsal side of *L* and displace the latter in ventrad direction. These are the significant elements of what I have termed "U-type" of sutural development. Its differences from the "A-type" will become apparent by a comparison of the Text-figures 2 and 1.

The "U-type" is characteristically developed especially in the group of prolecanitids. This indication by the juvenile specimen is justified further by two larger individuals with a diameter of 5 mm. (Pl. 121, figs. 5a,b) and 30 mm. which seem to belong to *Protocanites gurleyi* (Smith). The suture lines of these specimens (the larger of which comes from the Exshaw formation near Fernie, approximately 200 miles south of the main locality) are added in Text-figures 2e and f. They represent a direct continuation of the development initiated by the adolescent form.

3. A further developmental type of the suture line is represented by three young specimens. Even in their exterior shape they differ from the other forms by the larger size and broadness of the protoconch, by a strange flattening and bending at the beginning of the first whorl, and by a slight depression of the ventral side (Pl. 121, figs. 2–4, to be compared with Pl. 121, figs. 1,6 and Pl. 120, figs. 1–7, all of the same magnification).

The primary suture of this type (Text-fig. 3a) resembles that of *Imitoceras* (Text-fig. 1b), but the further development is quite different. There is no identation by an adventitious lobe at the top of the broad saddle between *E* and *L*. Instead, the further elaboration of the suture line takes its origin from the ventral lobe *E*, which is subdivided into three partial lobes (Text-figs. 3b-d; Pl. 121, figs. 4,3b). From the basal side-walls of the lobe two saddles arise, originally very shallow, but growing successively higher; a sort of a median saddle in the most advanced suture observed. It is the same kind of development which can be observed in Upper Devonian praeglyphioceratids and manticoceratids. For brevity, we may call this modus of an augmentation of lobes from the ventral lobe the "E-type."

The difference can be expressed by formula. In one case (*Imitoceras*) the differentiation of suture line is brought about by a subdivision of the saddle E/L, in the second case by a partition of the lobe E. Theoretically the first process may eventually grade into the second. In some genera (*Cheiloceras*, *Tornoceras*) the adventitious lobe is not formed exactly at the top of the saddle, but somewhat on its ventral slope (Schindewolf, 1929). It could be imagined that by further shifting in position, a condition resembling our case might be reached. However, in most cases it is possible to discriminate between the splitting of the saddle and that of the lobe; in our instance the difference is obvious.

Unfortunately we do not possess larger specimens and are not able to observe the further development of the suture line. A definite generic determination is therefore impossible. In the behavior of the ventral lobe, however, a similarity seems to exist with that of *Prodromites*, diagrammatically represented by A. K. Miller & C. Collinson (1951). The ventral lobe of that genus is split apparently in the same manner, but at the stages when this process is starting, a number of further lobes is already developed toward the umbilical seam. An identification of our form with *Prodromites* is not admissible, but some similarity in the direction of *Prodromites* can be asserted.

The above-mentioned Upper Devonian goniatites cannot be taken into consideration, for the fission of their ventral lobe takes place at a considerably later stage of development. The precession of this character to the very first sutures points to a more advanced, *i.e.*, geologically younger, goniatite—possibly a new genus.

ORTHOCONIC CEPHALOPODS

Less significant than the coiled goniatites are the straight, more or less cylindrical cephalopods, which are present in a fairly large number. They partly bear protoconchs which are rarely preserved in such forms; some of them are figured (Pl. 120, fig. 12; Pl. 121, figs. 7–10). Where the siphuncle can be observed, it has an extreme marginal position. The suture line shows a shallow dentiform lobe at the siphonal side and a more or less pronounced saddle at the opposite, antisiphonal, side.

The possession of a siphonal lobe together with the small ventral siphuncle is the diagnostic character of the bactritids. I am referring these forms, presumably several species, to *Bactrites* s.l. According to my earlier deductions (Schindewolf, 1933), I regard the bactritids as primitive uncoiled members of the goniatites, which which they agree—setting aside their straight conch—in the important diagnostic criteria of the bulbous protoconch, the small ventral siphuncle, and the character of suture line. Others may prefer to classify them with the nautiloids. Actually, this does not make an important difference; that the bactritids are the ancestors of the oldest coiled goniatites can be supported by new material. The bactritids are closely related to the goniatites, and it is merely a question of convention whether to include them in the nautiloids, or to unite them with the goniatites.

Explanation of Plate 120

The specimens illustrated on this plate are from the Exshaw formation near the Brazeau River, Jasper Park, Alberta. They are deposited in the Hamilton College, McMaster University, Hamilton, Ontario, and catalogued under the numbers added in parenthesis.

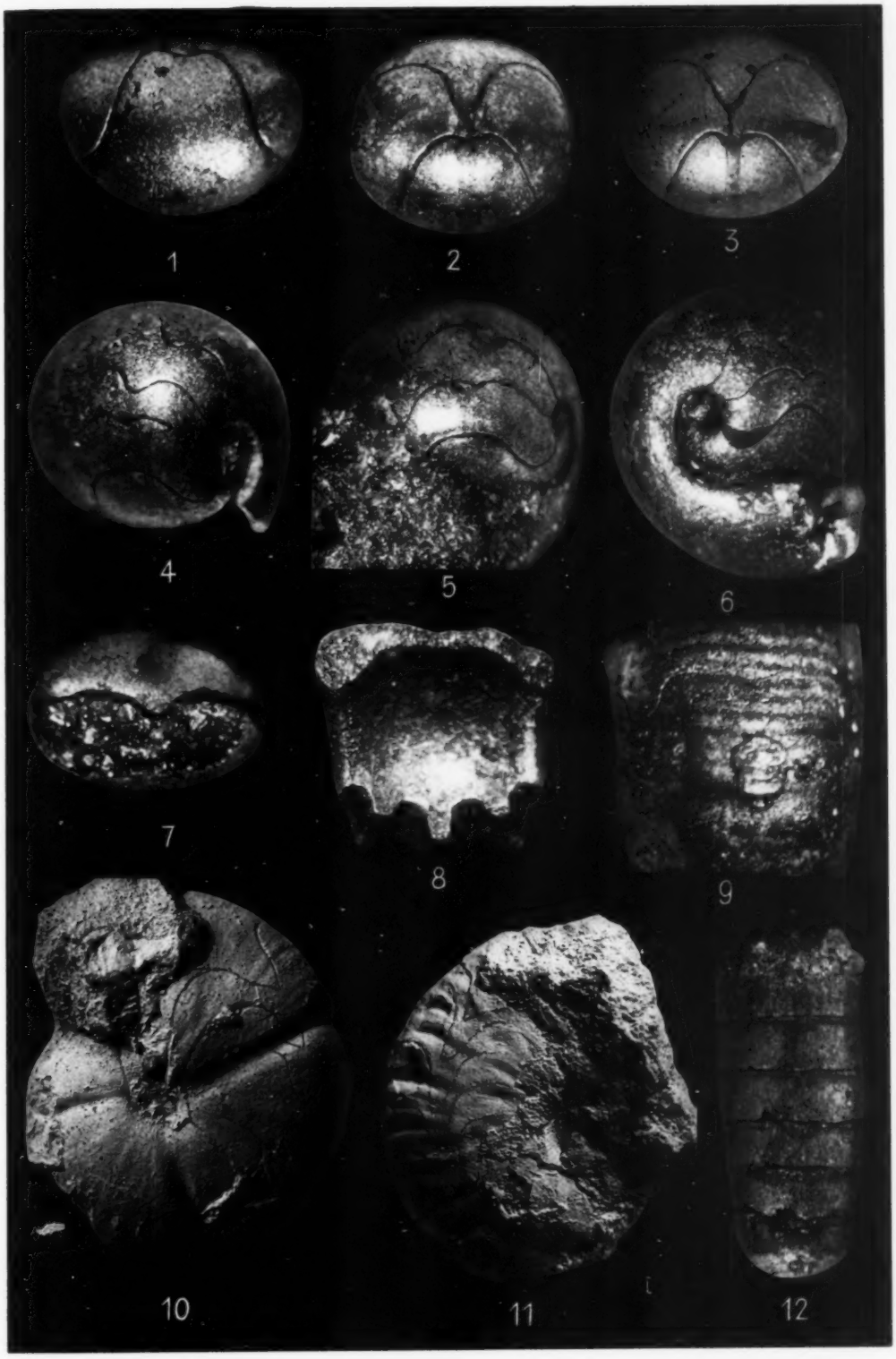
Figs. *1–8*—*Imitoceras* sp., development of suture line, all ×40. *1* (CM1), Prosuture; *2*, (CM2); *3* (CM3), prosuture and primary suture; *4* (CM4); *5* (CM5); *6* (CM6), formation of the adventitious lobe in the second suture line; *7* (CM7), dorsal part of the primary suture; and *8* (CM8), dorsal suture of a later developmental stage.

9—*Imitoceras* sp., ventral side with ribs at a diameter of 1.5 mm. (CM9), ×40.

10—*Imitoceras* cf. *I. discoidale* (Smith) (CM10), ×4.

11—*Imitoceras* sp. (CM11), ×4.

12—*?Bactrites* sp. (CM18), siphonal side, ×40.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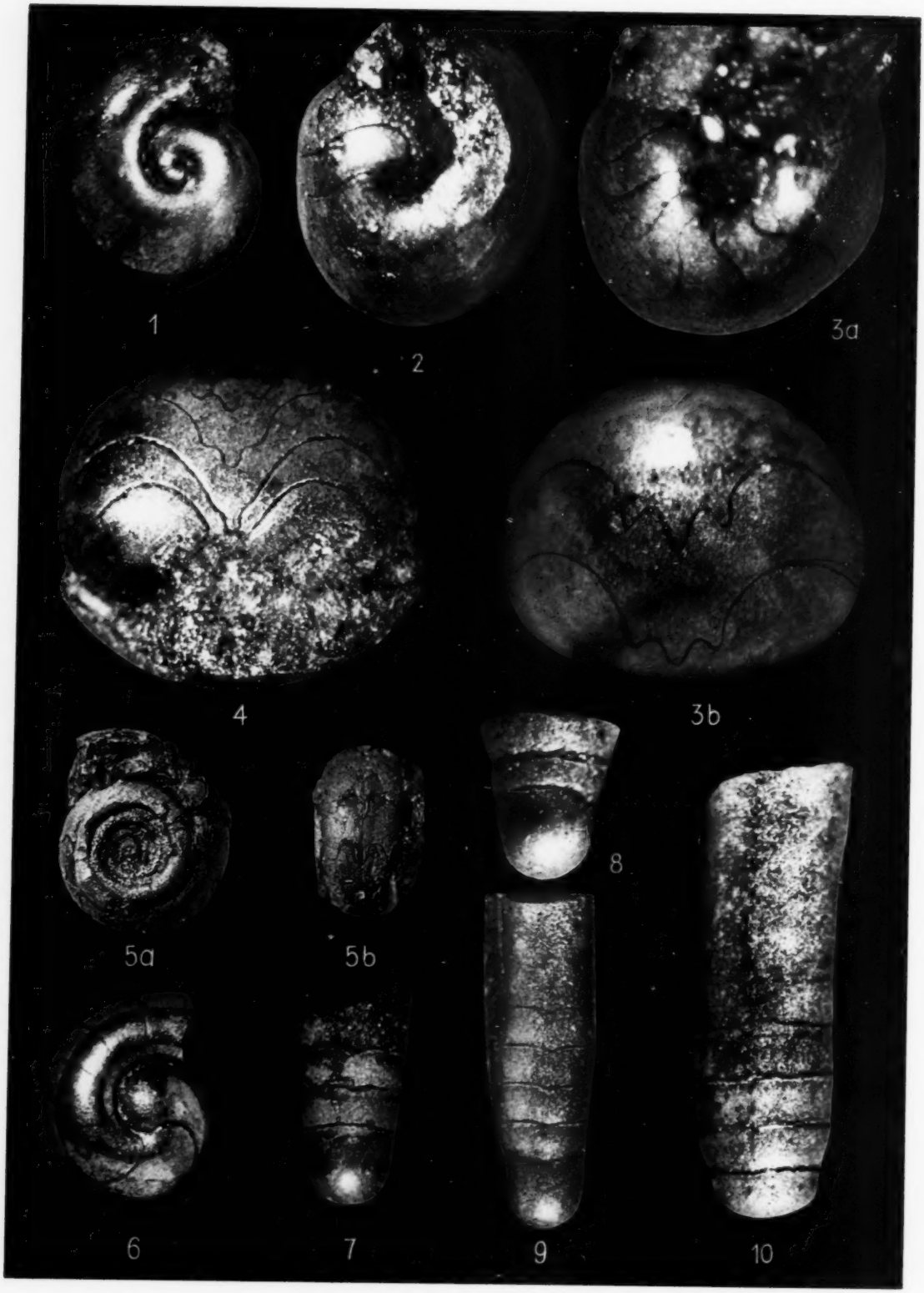
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CONCLUSIONS

1. The much debated age of the black Exshaw shale was originally considered as Lower Mississippian by R. G. McConnel, H. W. Shimer, P. S. Warren, and others. Later, Warren discovered some crushed goniatites which have been tentatively determined by A. K. Miller as *Tornoceras* (*Tornoceras*) cf. *uniangulare* (Conrad). This identification led Warren (1937) and Miller (1938) to suppose an Upper Devonian age of the Exshaw formation, a view still maintained in 1956 by P. S. Warren & C. R. Stelck. According to Warren the unit may be correlated with the Three Forks shale of Montana.

In the meantime, C. H. Crickmay (1952) also found goniatites which he identified as "*Aganides* sp. close to *A. discoidalis* Smith." He thereupon dated the Exshaw shale as earliest Mississippian. Recently, C. B. Pamenter (1956) described a small goniatite which was determined by A. K. Miller & W. M. Furnish likewise as *Imitoceras* aff. *discoidale* (Smith) and which may represent an early growth stage of the large Exshaw goniatites without completely preserved suture lines ("*Tornoceras*"). Pamenter was thus inclined to ascribe a Mississippian age to the Exshaw formation.

This assignment is fully confirmed by our specimens of *Protocanites* cf. *gurleyi* (Smith). It further would be corroborated if our supposition could be verified that one of the goniatite types is related to the genus *Prodromites*. The Exshaw formation is thus definitely of Lower Mississippian age and probably equivalent to the Chouteau formation of Missouri (Tournaisian of European terminology). A correlation with the considerably older Three Forks formation of Montana (Schindewolf, 1934) is impossible.

2. The comparison of a large number of protoconchs and early stages of suture lines proved the constancy of the different developmental types and confirmed the author's views of their phylogenetical significance. Beginning from the very early stages, our three goniatites are different and determinable (of course not specifically, but as far as the larger evolutionary branches are concerned to which they belong). Arkell and Spath thus were incorrect when they designated these fundamental differences as "unimportant and variable features."

3. Methodically, it may be of some interest that, even with such early adolescent growth stages of goniatites, approximate age determinations can be achieved.

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EXPLANATION OF PLATE 121

The specimens illustrated on this plate are from the Exshaw formation near the Brazeau River, Jasper Park, Alberta. They are deposited in the Hamilton College, McMaster University, Hamilton, Ontario, and catalogued under the numbers added in parentheses.

FIG. *1*—*Imitoceras* sp. (CM12), ×40.

2–4—Gen. indet. aff. *Prodromites*, all ×40. *2* (CM13); *3a* (CM14), lateral views; *3b* (CM14), somewhat advanced stage in the development of the ventral lobe; and *4* (CM15), early stages in the development of the ventral lobe.

5–6—*Protocanites* cf. *P. gurleyi* (Smith). *5a,b* (CM16), Two views of the same specimen, ×6; and *6* (CM17), early adolescent stage, ×40.

7—*Bactrites* sp. with preserved protoconch, siphonal side (CM19), ×40.

8—*?Bactrites* sp. with preserved protoconch, (CM20), ×40.

9—*Bactrites* sp. with preserved protoconch, siphonal side (CM21), ×40.

10—*?Bactrites* sp., antisiphonal side (CM22), ×40.

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JOURNAL OF PALEONTOLOGY, V. 33, NO. 6, P. 977–985, PLS. 122–123, 3 TEXT-FIGS, NOVEMBER, 1959

SAPPINGTON (KINDERHOOKIAN) SPONGES AND THEIR ENVIRONMENT

R. C. GUTSCHICK AND T. G. PERRY
University of Notre Dame, Notre Dame, Indiana; Indiana University, Bloomington

ABSTRACT—Nodular limestone strata in the lower part of the Kinderhookian Sappington sandstone of southwestern Montana contain a spongiostromatid algae and sponge association that would suggest a shallow water algal bank environment. Fossil sponges of the genus *Scaphiomanon*, n. gen., which includes two species, *Scaphiomanon nodulosum*, n. sp., and *Scaphiomanon hadros*, n. sp., are described from this zone. Similar nodular limestone beds are also present in the Leatham formation of the Logan, Utah area and the Midridge limestone of the Confusion Range, Utah.

INTRODUCTION

DURING several summers of field work associated with Indiana University Field Station in southwest Montana, attention was drawn to the Sappington sandstone in its type area. The formation is principally a siltstone but it also contains calcareous beds, particularly in the lower part. The peculiar nodular limestone unit at its base is in strange contrast to underlying and overlying beds. Close examination of the nodules revealed their organic nature as an algal-sponge association. The fossil sponges were collected during three summers from this zone and form the basis of this study.

We are grateful to Dr. Judson Mead for his encouragement in the study and help in collecting material. Students John Weiner, Jon Jacoby, and Leighton Young also helped to collect specimens from both localities.

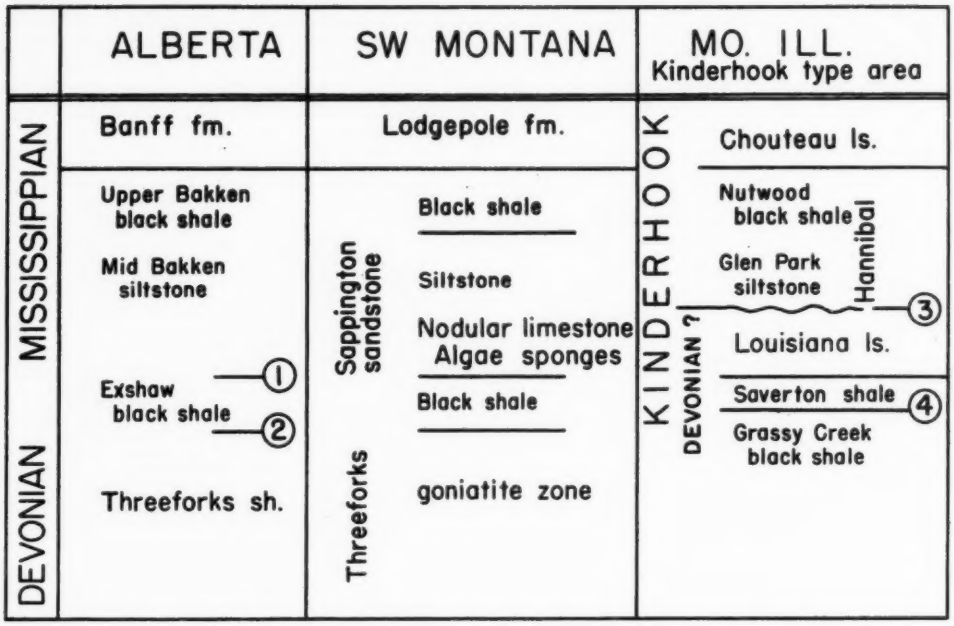
Berry (1943) designated the yellow sandstone between the underlying Threeforks shale and the overlying Lodgepole limestone in the Three Forks area as the Sappington sandstone. Holland (1952) gives a more detailed account of the type section which includes 4 feet of calcareous sandstone in its lower part with brownish or reddish limestone nodules. It is this zone of nodules which contains fossil algae and sponges. Gutschick and Perry (1957) describe two other well exposed sections of the Sappington which also include the nodular algal-sponge zone.

It is not the purpose of this paper to try to resolve the Devonian-Mississippian boundary in southwest Montana which, in turn, would establish the age of the Sappington. Nevertheless, a summary of the status of the stratigraphy of this portion of the section is in order. In 1952, a collection of goniatite cephalopods was made from the Upper Devonian Threeforks shale at the Red Hill Section along the north slope of a small gully in the northeast corner of the $SW\frac{1}{4}$, $NE\frac{1}{4}$, $SW\frac{1}{4}$, sec. 22, T. 2 N., R. 3. W., Jefferson Island Quadrangle, Jefferson County, Montana. Some 137 specimens were collected from shale 15 to 20 feet below the base of the Sappington algal nodule zone. A. K. Miller (personal communication, Nov. 22, 1952) identified the following forms in this collection:

Platyclymenia (*Pleuroclymenia*) *americana* (Raymond)
Bactrites nitidus Raymond
Tornoceras (*Tornoceras*) *crebriseptum* Raymond
Raymondiceras simplex (Raymond)

The above fauna represents the *Platyclymenia* stage of the Famenian of Europe (Miller, Furnish, & Schindewolf, 1957). The late Devonian *Clymenia* and *Wocklumeria* stages have not been recognized.

Workman & Gillette (1956) summarize the stratigraphic relations of the Kinderhook Series in its type area. This includes the Louisiana limestone. Schuchert (1910), Holland (1952), Laudon (1955) and other geologists have recognized a fauna in the Sappington which is very similar, if not identical, to the fauna of the Louisiana limestone of Missouri. This fauna is best developed in the zone of algal nodules in the lower part of the Sappington.



TEXT-FIG. *1*—Correlation of Kinderhook rocks in southwest Montana. (Modified from Workman, 1958; type area from Workman & Gillette, 1956.) Numbers in circles indicate Devonian-Mississippian assignments by the following:

1. Workman, 1958, suggests this correlation.
2. Harker & McLaren, 1958.
3. Branson & Mehl, 1933.
4. Williams, 1943, 1957, indicates that Grassy Creek may be either Devonian or Carboniferous.

Workman (1958) in a discussion of Carboniferous papers on western Canada presents an interesting section showing the possible relationship of Devonian-Mississippian (Kinderhook) black shale and sandy units in Alberta, Illinois, Indiana, and Michigan. We have modified this in Text-figure 1 by adding the southwest Montana section. Following Workman's suggested correlations, the southwest Montana sequence conforms very well. There is a similar black shale-siltstone-black shale sequence corresponding to the Exshaw-Bakken beds of Alberta and the Grassy Creek-Glen Park-Nutwood units of the Mississippi Valley area. The nodular limestone and its fauna is also in the appropriate position for correlation with the Louisiana limestone of the Missouri-Illinois section. Text-figure 1 shows the various published opinions concerning the stratigraphic position of the Devonian-Mississippian contact. Additional elements of the fauna and flora for this stratigraphic sequence will have to be studied before a thorough analysis can be made.

LOCALITIES

Sponges were collected from the following two localities where they are common:

Locality 1. Antelope Creek Section. SE¼, NW¼, NE¼, sec. 2, T. 1 S., R. 2 W., about 2 miles west by southwest of the village of Sappington, Jefferson Island Quadrangle, Madison County, Montana (Gutschick & Perry, 1957,). Sponges occur in place along the north side of the draw and also weather free along the slope. A few large rounded specimens were found in the bottom of the draw where they rolled some 50 to 75 feet down the slope. About 25 or more specimens were found at this locality.

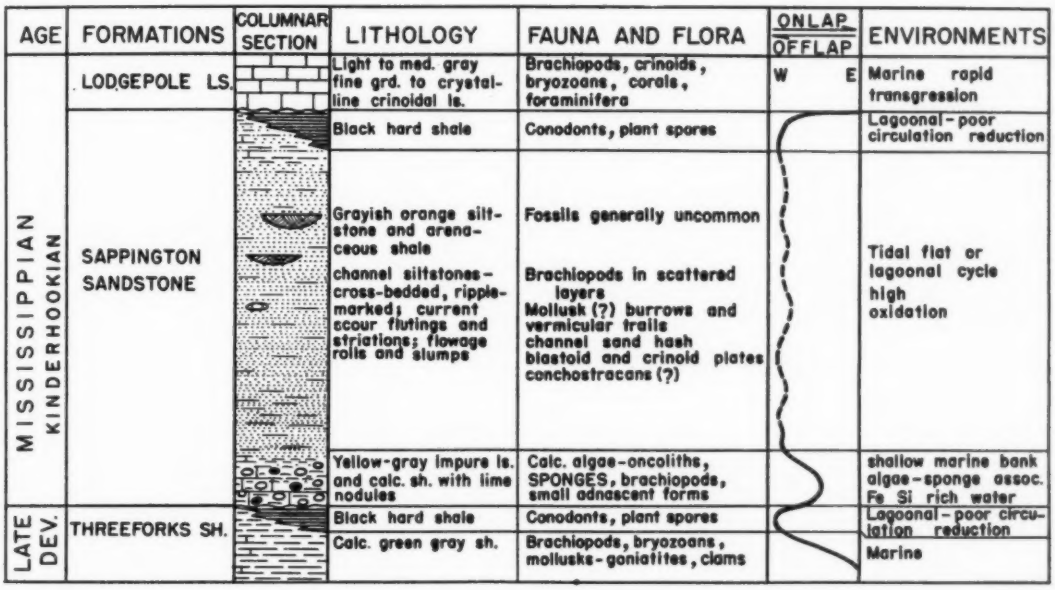
Locality 2. Milligan Canyon Section. Type section of the Sappington sandstone. NW¼, sec. 36, T. 2 N., R. 1 W., about 5½ miles west of the town of Three Forks,

Three Forks Quadrangle, Jefferson County, Montana (Berry, 1943; Holland, 1952). Sponges were collected from the outcrop in place and also weathered out along the slope. About 15 specimens were obtained from this locality.

PALEOECOLOGY

The stratigraphic sequence and generalized environmental interpretation of the Sappington sandstone and associated rocks is given in Text-figure 2. The sponges are restricted to the nodular limestone zone in the lower part of the Sappington formation. This distinctive zone is characterized by pebble- to small cobble-sized gray to reddish-brown limestone nodules scattered throughout a yellowish-gray silty argillaceous limestone matrix. The nodules weather free and form a rubbly-sloped surface. Nodules in this stratigraphic position are widely distributed. In Montana they occur in the Milligan Canyon Section, type for the Sappington, as well as in the Logan Section, type for the Madison group (Holland, 1952). They also are found in the Antelope Valley and Red Hill Sections (Gutschick & Perry, 1957). The nodule zone is recognized by McMannis (1955) in the Bridger Mountains and Nixon Gulch (Horseshoe Hills) Sections in Montana. In Utah, Holland (1952) indicates the presence of the nodule zone in the Leatham formation and uses it as one of the criteria for correlation of this formation with the Sappington of Montana. Laudon (1955) recognizes the nodules, which he regards as concretions, in the base of the Midridge limestone in the Confusion Range of west-central Utah. We find that the nodule zone is exposed in very few places because it is usually covered by hill-wash from the overlying cliff-forming Madison limestone. Therefore, it is difficult to determine the complete extent of this bed.

Most nodules have the complete brach-



TEXT-FIG. 2—Generalized diagram summarizing stratigraphic and environmental relationship of sponge biostratigraphic zone.

iopod shell *Rhipidomella missouriensis* (Swallow) making up their centers. The nodules display thin wavy concentric laminae around the brachiopod shell. Many small fossils occur between the thin layers. We regard the nodules as calcareous algae of the Family Spongiostromata having well-defined external form, little or no microstructure in thin section, and growth form generally of same shape and size as the nodule (Johnson & Konishi, 1956). The colonies are unattached and should be classified as oncolites. Nodules which are split and have their fractured surface differentially etched by natural weathering exhibit their wrinkly layered structure better than thin sections (Pl. 122, fig. 2). The outer surface of the nodule tends to be parallel to the growth layers. Hydrochloric acid residues of the algal nodules yield small siliceous fossils. These organisms grew attached to the algae and include tiny cup corals (embryonic?), spiny brachiopods (productids), craniaceans, fenestellid bryozoans, calcareous worm tubes (spirorbids), vermicular Foraminifera, and other animals.

The sponges are bowl-shaped, prolate-ellipsoidal, or ovoid with fairly deep cloacal cavities filled with lime mud. They are found *in situ* in various positions indicating that some have been rolled over and around. Most are only slightly compressed or deformed so that it is evident that they had hard rigid skeletons firmly lithified before burial and compaction. Their slight obliqueness may have been due to the position that they assumed in life to give the oscule greater cross-section to the currents.

The calcareous algae with the small adnascent animal fossil forms and the sponges make up the major portion of the biota, but other fossils are scattered throughout the bed between the nodules. These are spiriferids including syringothyrids, orbiculoids, crinoid fragments, clams, snails, ostracodes, and other forms. The overlying siltstones have channel fill cross-beds which contain fragmental echinoderm hash. Ostracodes and conchostracans (?) also are found in this detritus.

The algae and sponges are a dark limonitic brown color. It was this color contrast, along with the shape and structure of the sponges, that first attracted our attention to them. Sections were observed along joint fractures where they had oxidized differentially. The insoluble residues contain a rather large percentage of silica replacing the fossil forms and finely divided limonite. No siliceous sponges or any other forms that may secrete a siliceous skeleton were found in the biotope. This would not include aggilutinate foraminifers which are found in the fauna. The algal nodules when dissolved in HCl leave thin shells of limonite. Animal skeletons attached to the various layers of the algae are siliceous so that organisms which normally secrete calcareous skeletons are replaced by silica. Anderson (1950), who studied Lower Carboniferous algae (Spongiostromata) of northern England and southern Scotland, also found fossils to be high in silica and iron.

Examination of the stratigraphic sequence of Threeforks shale, Sappington sandstone, and Lodgepole limestone indicates that the Sappington lies between two major marine invasions. The black shales, nodular limestone, and siltstone beds represent a regressive phase of marine sedimentation. The black shales that are found below the nodular limestone and above the siltstone indicate shallow anaerobic lagoonal swamp conditions. At least two biotopes are represented in the Sappington—the algal-sponge nodular limestone zone and the siltstone facies with its fauna. The faunal and floral assemblage clearly indicates the algae-sponge zone to be marine. Its position between underlying black shales of lagoonal deposition and the overlying clastic siltstones formed under tidal flat conditions favor a very shallow water environment for the algae-sponge biota. From the information on the distribution of this biotope, it appears that it is developed parallel to the early Mississippian Cordilleran geosyncline. We interpret the environment of the algae-sponge assemblage as a shallow marine bank (biostromal) along the margin of the geosyncline. It represents a transitional stage of a retreating sea. Cloud (1942) suggests that marine stromatolites develop in water which is probably less than 100 feet in depth. Recent work by Ginsburg (1955) and Newell (1951) along the Gulf Coast and in the West Indies suggests that the greatest development of algae (Spongiostromata)

may be in very shallow water close to low tide level. Rezak (1959) in his study of stromatolites from the Belt series in Montana offers a classification of calcareous algae based upon their environments. He suggests that oncolites (unattached spheroidal bodies) occur in a shallow marine environment in which water depth is from 1 to 6 feet. DeLaubenfels (1957) states that the Calcispongea live only in shallow water of full oceanic salinity at depths of about 100 meters or less and are much more abundant at depths of less than 10 meters than elsewhere. He also states that larger individual sponges occur in subtropical waters. DeLaubenfels (1936) says that sponges are destroyed by silt which may account for their absence in the siltstone facies of the Sappington.

Ecologically, the Sappington algal "bank" may have been similar to the algal shoal areas described by Lochman (1957) except that the Cambrian algae are principally stromatolites attached to the bottom whereas the Mississippian forms are unattached. Okulitch and Nelson (1957) point out that only three genera of Mississippian sponges are known and thus do not comment on possible ecological trends shown by sponges during this period.

SYSTEMATIC PALEONTOLOGY

Classification of sponges has been based largely on modern forms. Among the more important bases for classification are nature, largely form, and composition of skeletal elements or complete skeleton. This would include wall structure, type of canal system, size and shape of cloaca, and size, shape, and association of spicular elements. Classification of fossil sponges is more difficult because their skeletal elements may be partially destroyed, replaced, or deformed.

The classification of Sappington sponges presents a difficult problem. If one follows DeLaubenfels' classification (1955) of sponges, it is necessary to know the composition and forms of the complete skeleton and the type of canal system. The Sappington specimens have well formed rigid skeletons which are presently calcareous. Except for faint suggestions of spicules which are apparently present, none has been identified either from thin sections or residue studies. The sponge wall has prominent vermiform canals. King (1943), in referring to the Calcispongea, states that recognizable spicules are rare in fossil calcisponges; commonly the spicular parts of the sponge are preserved as a fibrous mass. He continues that a massive wall penetrated by numerous irregular vermiform canals, as in *Maeandrostia* Girty, suggests a calcisponge. This would certainly apply to the Sappington sponges. Prior to publication of the Treatise (DeLaubenfels, 1955), it would have been logical to classify the Sappington forms in the pharetrones, a division of the Heterocoelida based upon their thick walls and irregular canals. Lacking the exact nature of the sponge architecture and spicular types, we are provisionally placing the Sappington sponges in the Class Calcispongea leaving the subdivisions uncertain.

Phylum PORIFERA
Class CALCISPONGEA (?) de Blainville, 1834
Order UNCERTAIN
Family UNCERTAIN
Genus SCAPHIOMANON Gutschick & Perry, n. gen.

Type species: Scaphiomanon nodulosum Gutschick & Perry, n. sp.

This genus is characterized by a rather large well-formed globular bowl-shaped calcareous skeleton which has thick robust walls. The cloaca varies in size and shape but is generally wide and deep. The oscule is wide and roughly circular and is surrounded by a prominent round-edge rim. The thick wall is traversed by many transverse large irregular vermiform canals. Except for their transverse arrangement, there does not seem to be any discernible regular pattern.

The exterior of the sponges has an irregular pebbly surface which is granular and finely pitted. Such surface is due to numerous circular to elliptical depressions formed where the canals emerge surrounded by a scattered distribution of intervening small bumps or rounded projections. Although the sponges were probably attached in life, the area of attachment probably was small because the lower ends of the fossils are bluntly rounded and show no evidence of a broken anchor. There is a great deal of un-

certainty concerning the nature of the spicules.

The generic name refers to the bowl-like shape of these sponges.

SCAPHIOMANON NODULOSUM Gutschick & Perry, n. sp.
Pl. 122, figs. 1,3–9; Pl. 123, figs. 3–5; text-fig. 3A–F,H

This commonest of Sappington sponges is of variable size and shape. The skeleton usually has a flattened spheroidal bowl-shaped form. It may also be elliptical in horizontal section and has an upper central depression for the oscule and cloaca. It has a thick-walled skeleton composed of iron-rich calcium carbonate which accounts for its stoutness and rigidity.

The cloaca is usually well-defined, wide, and fairly deep. It is bowl-shaped with the maximum diameter equal to that of the diameter of the oscule. The oscule is evenly circular to elliptical and has a prominent narrowly rounded raised rim surrounding it. Openings of canals may intersect the rim and give it a serrate edge with rounded projections.

The skeleton walls tend to be evenly thick and well-defined except towards the oscule where they narrow down into the rim. Numerous vermiform canals extend through the wall but it is difficult to recognize any particular pattern in order to classify the type of canal structure. The canals extend more or less normal to the inner and outer wall surfaces although there are occasional lateral passages. Numerous sections, vertical, horizontal, and tangential, were chosen to illustrate the nature of the canal structure. Plate 123, figure 4 shows a tangential section which indicates the cross-sectional shape of the canals. Intersection of the canals and the outer wall surface produces numerous scattered depressions over the surface which, with the intervening rounded raised portions, give the surface an irregular or pebbly-spotted pattern. This external appearance is of assistance in recognizing the sponges more readily on the outcrop and gives them close resemblance to some algal oncolites. Spicules are faintly discernible in the skeletal wall in thin sections but are difficult to identify. The forms display some asymmetry which suggests deformation while they lived or after burial. This slight obliquity may be due to their normal living position on the sea floor. The sponges are associated with numerous algal nodules or oncolites and form part of a biostrome.

Some thirty or more specimens of *Scaphiomanon nodulosum*, n. sp., were found from the two localities. About half of the specimens are complete well preserved mature individuals, and eleven of these are figured in this report. Measurements of the holotype are: greatest diameter-maximum 82 mm., minimum 65 mm.; height 45 mm.; diameter of oscule 32 to 45 mm.; maximum diameter of cloaca 28 mm.; average thickness of wall 12 to 15 mm.; maximum diameter of canals 3 mm. The largest specimen found, Text figure 3-F, came from the Antelope Valley Section and measures: diameter 95 mm.; height 60 mm.; diameter of oscule and cloaca 60 mm.; height of cloaca 50 mm.; walls variable in thickness from 12 to 20 mm.; and maximum canal diameter 3 to 4 mm.

The specific name reflects the nodular appearance of the species. The holotype

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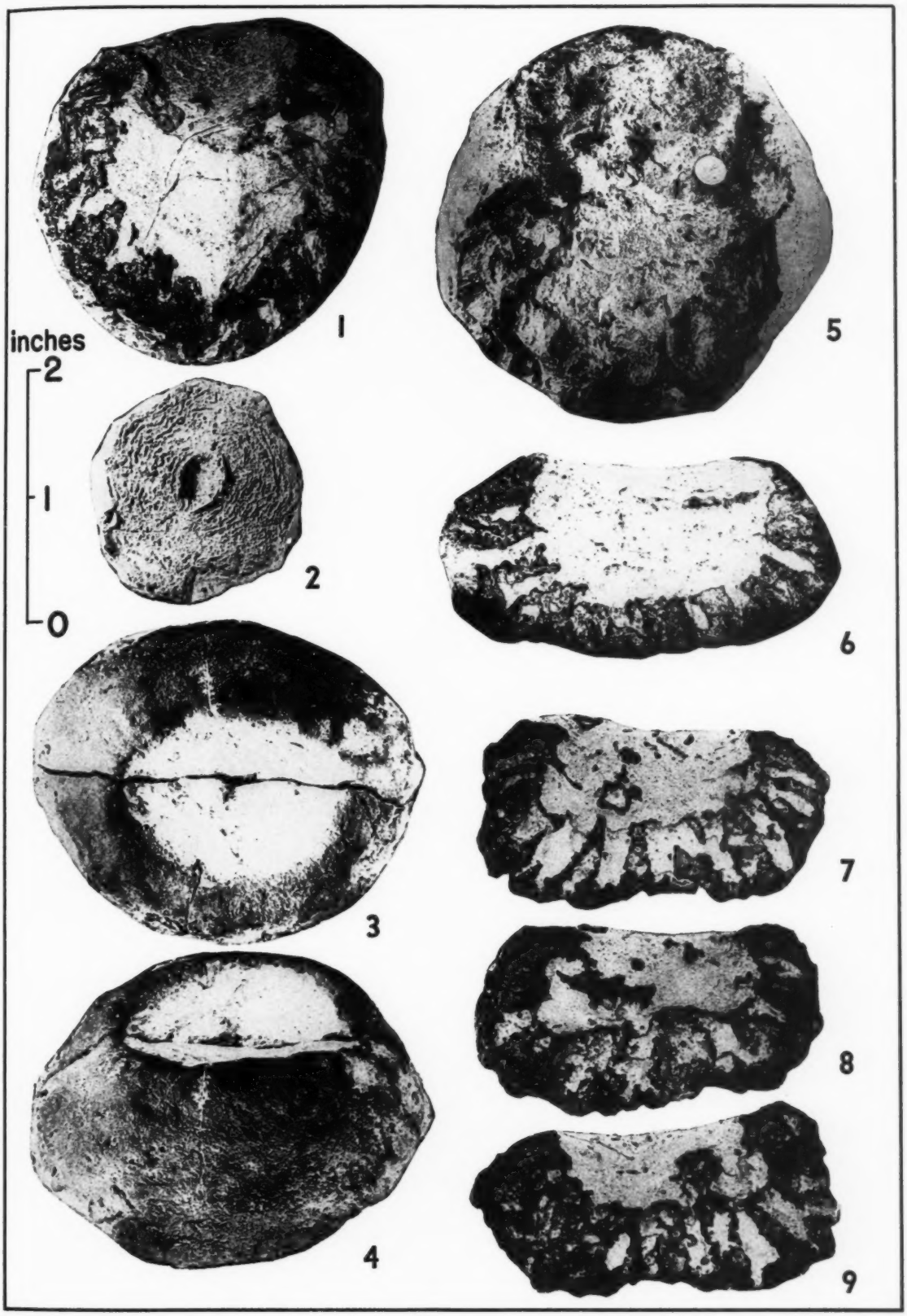
EXPLANATION OF PLATE 122

All photographs are unretouched; scale on left side refers to all illustrations.

FIGS. *1,3–9*—*Scaphiomanon nodulosum* Gutschick & Perry, n. gen., n. sp. *1*, Sagittal sections of sponge showing structure along two vertical planes of symmetry approximately at right angles to each other, upper part shows rim of osculum, paratype, USNM 137943; *3–4,6*, top, oblique lateral, and sagittal views, showing well shaped oscule and pebbly perforate surface of sponge, holotype, USNM 137942; *5*, oblique view of partly broken slightly distorted paratype showing oscule, cloaca, sagittal section of wall, and canal structure, USNM 137944; and *7–9*, sagittal serial sections giving details of cloacal cavity, wall, and canal structure, paratype, USNM, 137945–6; all from Locality 2.

2—Algal nodule, Family Spongiostromata. Nucleus of oncolite consists of a brachiopod shell probably *Rhipidomella missouriensis* (Swallow); note concentric growth pattern on natural weathered (etched) surface. Specimen is from Locality 1.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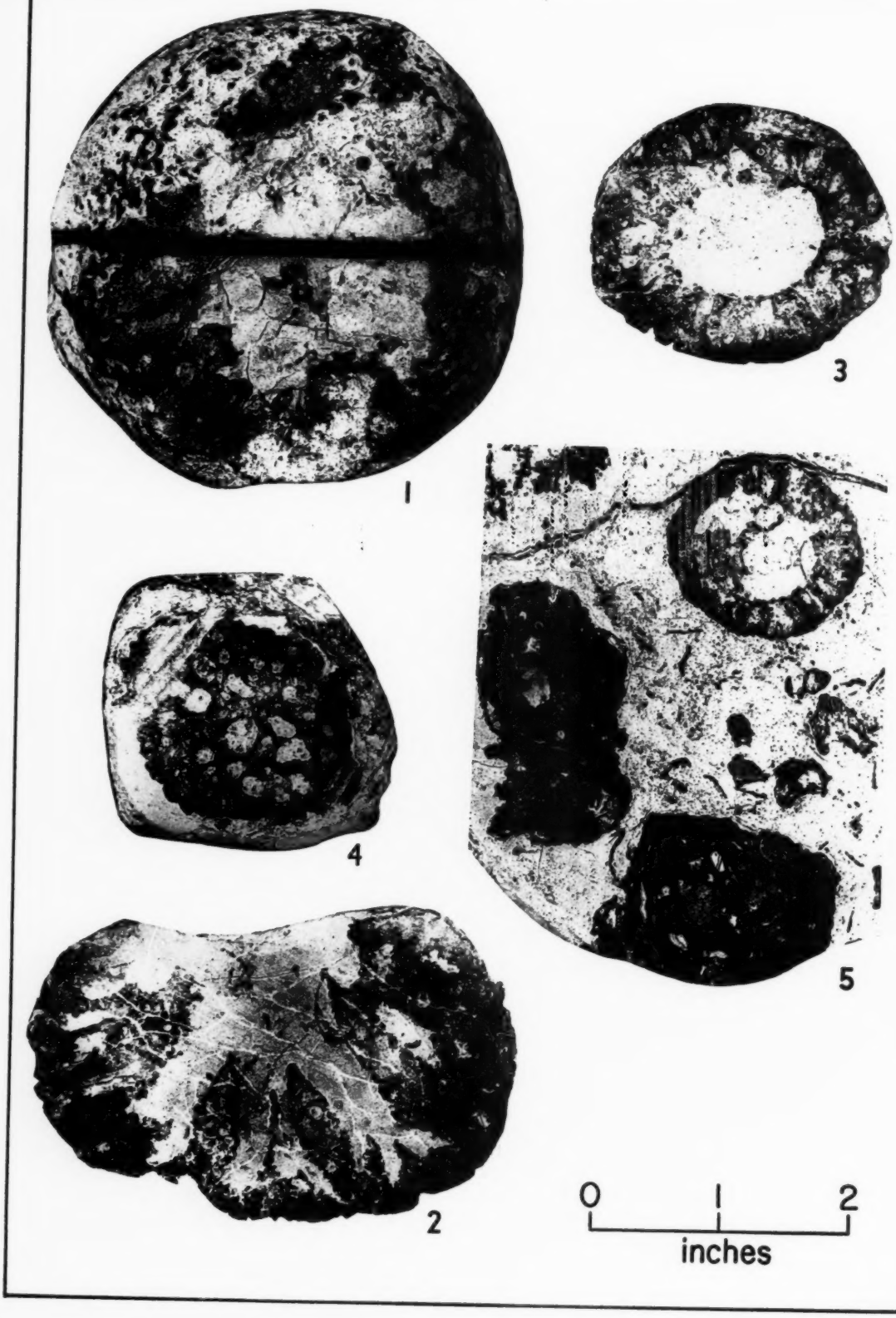
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comes from the type locality of the Sappington sandstone.

Types.—Holotype, USNM 137942; figured paratypes, USNM 137943–54.

Scaphiomanon hadros Gutschick & Perry, n. sp.

Pl. 123, figs. 1,2; text-fig 3G

This fossil sponge is a rather large stout thick-walled form with evenly prolate spheroidal shape. It has a very shallow cloaca, and the wall is traversed by coarse canals. The rigid skeleton is composed of calcium carbonate high in iron which is oxidized to a dark-brown color. This gives the sponge skeletal material sharp color distinction compared to the lighter color of the fine-grained argillaceous silty calcareous matrix which fills the canals and cloaca and also encloses the fossils.

The poorly defined cloaca is relatively small and irregular compared to the total volume and external shape of the sponge. It is about one-third the diameter of the sponge and one-third its height. The oscule appears to be roughly circular with a broad well-rounded rim surrounding it. The skeletal walls are unusually thick compared to *Scaphiomanon nodulosum*, n. sp. They are transected by large coarse irregular canals which connect the outside of the sponge with the cloaca. The large canals split so that the canals in the outer part of the wall structure are smaller. The type of canal system has not been determined. It may be that the three wide inner canals are part of the cloaca which would give more inner wall surface. The emergence of the canals on the outer wall surface produces depressions which give the exterior a pebbly irregular surface.

Scaphiomanon hadros, n. sp., is established from a single specimen found at Locality 1. Its greatest diameter is 98 mm.; height 61 mm.; diameter of oscule 39 mm.; average wall thickness approximately 35 mm.; maximum diameter of canals 10 mm., narrowing down to 2 or 3 mm. No spicules have been observed nor is there any visible place of attachment although the sponge is flattened or irregular off-center on the bottom.

Remarks.—*Scaphiomanon hadros*, n. sp., is characterized by being large, robust, and ellipsoidal bowl-shaped, and has thick walls, coarse canals, and a small poorly-defined cloaca. It can be distinguished readily from *Scaphiomanon nodulosum*, n. sp., which has a wide, deep, better defined cloaca and less thick even walls. Otherwise, it resembles no other form.

The specific name directs attention to the thick stout walls and the bulky nature of the species. The single large well-preserved specimen was found loose in the bottom of the narrow draw of the Antelope Valley Section.

Type-—Holotype, USNM 137955.

ADDENDUM

During the past summer while the paper was in press, additional field work was done by the senior author which turned up two other localities where the sponge fossils occur in association with algal nodules. This establishes their occurrence over a distance of 25–30 miles more or less normal to the trend of the early Mississippian Cordilleran geosyncline. The algal nodules are more numerous and larger where they occur with the sponges such as the four localities cited.

Locality 3. Section 2 miles east of Trident, Montana, along the bottom of a NE-SW strike valley from the center of the SW¼ to the SE corner of sec. 1, T. 2 N., R. 2 E., Manhattan Quadrangle, Gallatin County,

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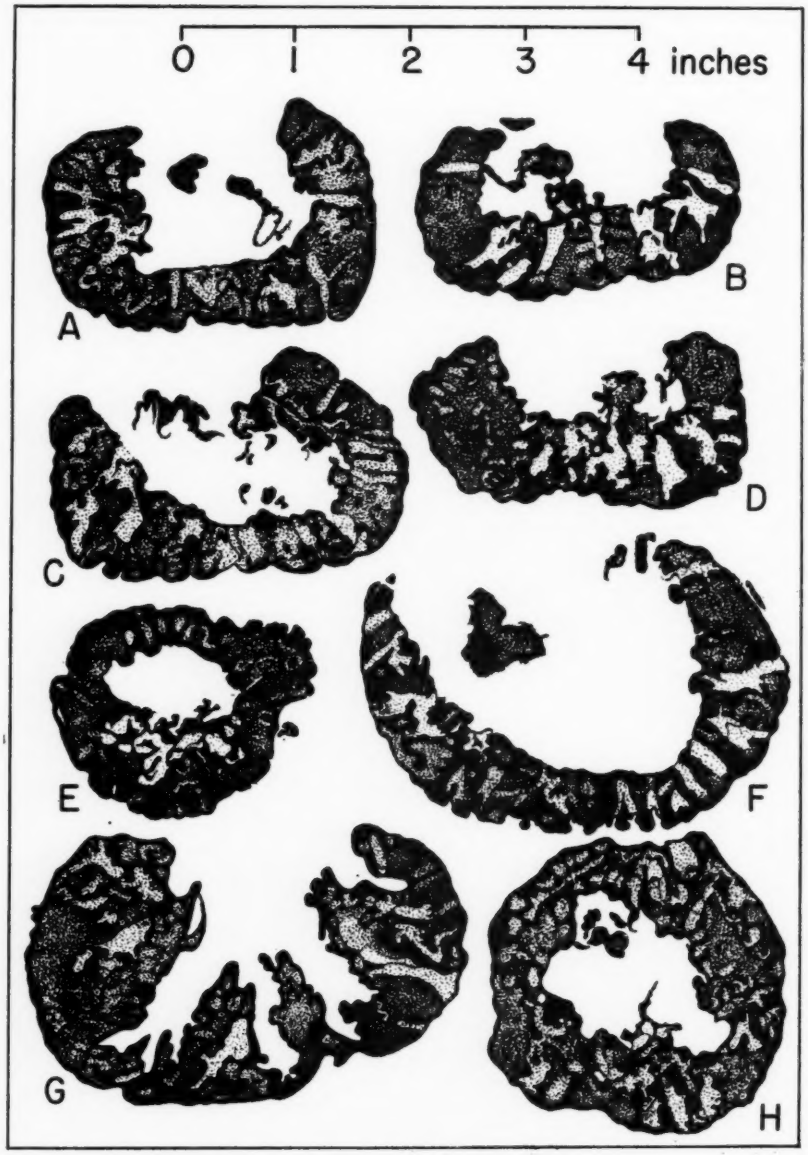
Explanation of Plate 123

All phtographs are unretouched. Scale refers to all illustrations.

Figs. *1,2*—*Scaphiomanon hadros* Gutschick & Perry, n. gen., n. sp. *1*, Top view of holotype with saw-cut and pebbly surface and *2*, sagittal section through median plane illustrating small size of cloaca and large coarse canal structure, holotype, USNM 137955, from Locality 1.

3–5—*Scaphiomanon nodulosum* Gutschick & Perry, n. gen., n. sp. *3*, Horizontal section; *4*, tangential section to show normal sections of canals; *5*, horizontal section of sponge associated with two algal nodules; paratypes, USNM 137947–9.



TEXT-FIG. 3—Generalized drawings (stippled) showing sagittal and horizontal sections of Sappington sponges.

A–F, H—*Scaphiomanon nodulosum* Gutschick & Perry, n. gen., n. sp.

A,C,F—Sagittal sections of specimens from Locality 1. USNM 137952–4.

B,D—Serial sagittal sections of specimen from Locality 1. USNM 137946.

E,H—Horizontal sections of specimens from Locality 1. USNM 137950–1.

G—*Scaphiomanon hadros* Gutschick & Perry, n. gen., n. sp.; sagittal section of holotype from Locality 1. USNM 137955.

Montana. Algal nodules and sponges are common at this locality which was called to our attention by Dr. Judson Mead.

Locality 4. Nixon Gulch Section of Sappington formation along the bottom of strike valley near the north center of $SW\frac{1}{4}$ and $N\frac{1}{2}$ of $SE\frac{1}{4}$, sec. 14, T. 2 N., R. 3 E., Manhattan Quadrangle, Gallatin County, Montana. Algal nodules are 2 to 3 inches in diameter and abundant. Sponges are common. Two specimens were found in place in contact with one another. One was right side up and the other atop it upside down.

Over 30 specimens of *Scaphiomanon nodulosum*, n. sp., were collected from these localities. One or two specimens may belong to *Scaphiomanon hadros*, n. sp.

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JOURNAL OF PALEONTOLOGY, V. 33, NO. 6, P. 986–1000, PL. 124, 3 TEXT-FIGS., NOVEMBER, 1959

FAUNAL ZONATION OF THE MINNELUSA FORMATION, BLACK HILLS, SOUTH DAKOTA

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Pasotex Petroleum Company, Oklahoma City, Oklahoma

ABSTRACT—An occurrence of Pennsylvanian upper Virgilian or Lower Wolfcampian fusulinids is described from the Minnelusa Formation in the northern Black Hills. Two additional fusulinid zones are reported from the same formation of the southern Hills. In addition, two conodont faunas are described and illustrated. These fossiliferous horizons, together with previously reported fossils, indicate that the Pennsylvanian portion of the Minnelusa is much thinner than has previously been reported.

INTRODUCTION

THE Minnelusa Formation of the Black Hills has attracted considerable attention since the time of its description by Darton at the turn of the century. It had long been considered Pennsylvanian in age, but as early as the 1930's some doubt appeared as to the true age relationships. On the basis of lithologic studies and physical correlation with other areas, the upper part came to be considered Permian in age, although no break between the two systems was recognized. Unfortunately, fossil evidence has, for the most part, been fragmentary and inconclusive. Faunal control of the lower portion of the formation has been more carefully worked out due to the relative abundance of fossils. The upper sands and carbonates have yielded few fossils.

Faunal collections were made throughout the Minnelusa outcrop in the Black Hills. Previously described localities were visited, and the author searched especially for fusulinids. Shale samples were collected at several localities to be examined for microfossils.

The principal exposures are: those along the northern flank in Bear Butte Canyon and Sand Creek Canyon, and along the southern flank in Beaver Creek Canyon, Hot Brook Canyon, and in the vicinity of Loring Siding. Exposures in Spearfish Canyon, Little Elk Creek Canyon, Rapid Canyon, Redbird Canyon, Hell Canyon, and along the west flank of the Black Hills were studied briefly.

The work was done under the direction of Dr. William M. Furnish. The writer is grateful to Shell Oil Company for financial assistance rendered while in the field and for helpful suggestions during the course of the work. In addition, the writer is indebted to Dr. M. L. Thompson for suggestions on fusulinid identifications, and to Dr. L. M. Cline for his contribution of fusulinid-bearing rock samples from the northern Black Hills.

PREVIOUS INVESTIGATIONS

Early workers in the area considered the Minnelusa to be Carboniferous in age. Few fossils were found, and it was not until 1909 that Darton assigned it to the Pennsylvanian on the basis of molluscan remains in the upper beds of the southern Black Hills. He considered the lower part of the formation to be Mississippian in age. However, in the Central Black Hills folio of 1925, Darton definitely assigned the entire sequence to the Pennsylvanian on the basis of furthre fossil evidence.

Dillé (1930) collected fossils from the basal red shale in the southern Hills and came to the firm conclusion that the basal beds of the Minnelusa Formation are "the equivelent of the Des Moines stage of the Carboniferous."

In the same year Roth (1930) described a section at Loring Siding in the southern Hills, 100 feet above the base of the Minnelusa, in which he recognized a fusulinid species which resembled *Fusulinella euthysepta* Henbest, and he also placed the lower portion of the Minnelusa in the Desmoinesian as the equivelent of the Cherokee.

Brady (1931) studied the Minnelusa Formation of the Beulah District in the

northwestern Black Hills, Wyoming, and traced four fossil bearing horizons through this area. On the basis of the megafauna collected, Brady ascertained that these forms were typical of the Missourian beds of the Pennsylvanian of the midcontinent region and suggested that the upper part of the formation in the northwestern Black Hills is "Upper Coal Measures" in age. Brady stated that his paleontological evidence of the upper beds, together with that of Dillé concerning the basal beds, indicated that sediments equivalent to parts of the Des Moines and to parts of the Missouri series are present in the Black Hills.

Thompson (1936) assigned an age slightly older than previous determinations to the basal units in the vicinity of Loring Siding where he described three new species of the primitive fusulinid *Fusulinella: F. dakotensis, F. furnishi,* and *F. acuminata.* On the basis of the relationships of these forms, Thompson designated the units as Lampasan in age.

In 1940, Condra, Reed, & Scherer published a correlation of the formations in the Laramie Range, Hartville Uplift, Black Hills, and western Nebraska. It was suggested that the upper beds of the Minnelusa might be Permian in age. This conclusion applied to the southern Black Hills was based on a correlation of the uppermost part of the Minnelusa with Division I of the Hartville Formation in Wyoming. All groups and formations as recognized in the Hartville Uplift were found to be present in this portion of the Black Hills. The upper 122 feet of the Minnelusa was assigned to the Permian, and identified with the Cassa Group. In addition, the underlying Broom Creek Group was recognized and 28 feet was assigned to an upper Pennsylvanian or Permian age. The correlation chart of the Pennsylvanian sponsored by the National Research Council in 1944 (Moore et al) stated, "The upper part of the formation probably contains Missourian and Virgilian deposits as indicated by the presence of fusulinids identified in Upper Pennsylvanian rocks of the Hartville Uplift. Paleontological evidence from the Black Hills is indecisive."

A correlation chart by W. O. Thompson and J. M. Kirby in the guidebook of the 14th Annual Field Conference of the Kansas Geological Society, 1940, indicates a Permian-Pennsylvanian boundary ranging from 60 to 100 feet above the base of the Minnelusa on the eastern and northeastern flank of the Black Hills.

Gries (1952) stated that the Minnelusa is Pennsylvanian in age. He concluded, however, that a comparison of faunal lists and fossil indentifications leads to contradictory conclusions and that it is not known how many epochs of the Pennsylvanian section of the midcontinent area are represented in the Black Hills.

Bates (1955) made a correlation of the Permo-Pennsylvanian formations of Wyoming and South Dakota and described a section of the Minnelusa on Beaver Creek near Wind Cave National Park in the southeastern Black Hills. On lithologic grounds, Bates suggested that the brecciated upper Minnelusa in the southern Black Hills is correlative with the upper evaporite zone in the subsurface Minnelusa. He further states: "The latter, in turn, appears contemporaneous with the upper Hartville ("Division I"), which Love, Henbest, & Denson (1953) consider to be Wolfcamp (?) in age. Gries (personal communication) states that there is as yet no paleontologic evidence from the Black Hills to refute or to support this correlation."

It is the conclusion of the present study, based on new faunal evidence, that the greater part of the Minnelusa in the northern Black Hills is Permian in age. Furthermore, the Permian interval in the southern Hills is considered to be of greater magnitude than has formerly been considered. Nevertheless, fossil evidence indicates deposits of Middle and Upper Pennsylvanian age are present throughout the Minnelusa outcrop.

STRATIGRAPHY

Northern Black Hills.—The Minnelusa is well exposed at several localities in the northern Black Hills. The formation averrages about 500 feet in thickness and varies only slightly around the outcrop. In general the formation can be divided into three to four lithologic units. At the base is a red shale or sandstone overlain by a varying sequence of carbonates, shales, and sand-

stones. The upper part of the formation is a massive sandstone and carbonate sequence capped locally by a chert or a cherty limestone. This general sequence is observed throughout the northern Hills except for an occurrence of evaporites in the upper portion farther west near Beulah, Wyoming.

Although fossils may be found, they are so poorly preserved that probably no precise identifications can be made. The fauna is predominantly brachiopod; most genera and species, as currently defined, have too great a stratigraphic span for use in detailed paleontologic zonation.

The writer verified the established zones of Dillé (1930) and Brady (1931) and in addition recognized two additional faunal horizons in the northern Hills. A previously undescribed occurrence of fusulinids is herein recorded from the Bear Butte Canyon (Boulder Canyon) section near Sturgis, South Dakota, in the $N\frac{1}{2}$, $NE\frac{1}{4}$, $SW\frac{1}{4}$, sec. 13, T. 5 N., R. 4 E., southeast of State Route 14A, Lawrence County. Though the fauna illustrated is not considered adequate for specific identifications, the stratigraphic significance of the occurrence of fusulinids in the northern Black Hills and its effect upon accepted correlations are of sufficient importance to warrant attention. The fusulinid zone was traced over a radius of approximately 20 miles from the outcrop in the northern Hills, found in Vanocker Canyon, north side of road cut, $N\frac{1}{2}$, $SW\frac{1}{4}$, $NE\frac{1}{4}$, sec. 32, T. 5 N., R. 5 E., Meade County, and in Little Elk Creek Canyon, 2 miles west National Forest Boundary on Dalton Road, $S\frac{1}{2}$, $NW\frac{1}{4}$, sec. 12, T. 3 N., R. 5 E., Meade County, South Dakota, along the eastern flank of the Hills. The zone occurs approximately 125 feet above the base of the formation in Bear Butte Canyon, and fusulinids were found in two dolomitic limestone beds separated by a thin sandstone.

A species of the genus *Triticites* is described and illustrated. On the basis of this study, the *Triticites* sp. from the Black Hills is considered to be upper Virgilian or Lower Wolfcampian in age, and that part of the Minnelusa from which it was obtained is correlated with the Waubaunsee Group or the lower part of the Council Grove Group in Kansas, the Wichita Group of north central Texas, the lower Wolfcampian of the Casper Formation in the Laramie Range and the upper Tensleep of the southern Big Horn mountains.

A conodont fauna is herein recorded from a partial section of the Minnelusa in Vanocker Canyon. Specimens were obtained from a thin gray shale occurring about 75 feet above the base of the formation. The fauna is well preserved and specimens are relatively abundant. Three species of the genus *Idiognathodus* and one species of the genus *Gondollela* are described.

Although the genus *Idiognathodus* ranges from basal Pennsylvanian to the base of the Permian, the species noted are strikingly similar to those of the Des Moines and Missouri series. Abundant specimens have been described from Kansas and Missouri in rocks of these ages. *I. magnificus* has been reported from the Cherokee through the Kansas City Groups of Kansas and Missouri, and the Upper Strawn and Lower Canyon series of north central Texas. Closely similar forms (*Idiognathodus iowaensis*, Youngquist & Heezen, and *I. mundulus*, Youngquist & Downs), have been reported from early Pennsylvanian shales of Iowa (Youngquist & Downs, 1949). *I. claviformis* has been reported from the Cherokee through the Bronson Group of Kansas and Missouri, the Upper Strawn and Lower Canyon series of north-central Texas, and the early Pennsylvanian of Iowa. In addition, McLaughlin (1947) reports a form with close affinities to *I. claviformis* from the Glen Eyrie Shale in central Colorado. *I. acutus* has been reported from the Cherokee and Marmaton groups of Kansas and Missouri and from early Pennsylvanian shales of Iowa. The genus *Gondollela* is quite restricted in the Pennsylvanian and has been reported from the Bronson and Kansas City groups of Kansas and Missouri, from the Lower Canyon series of north central Texas, and from the McLeansboro Group of western Illinois. Some isolated occurrences have been recorded from the Shawnee and from the Cherokee and Marmaton of Kansas and Missouri.

The presence of an upper Virgilian or Lower Wolfcampian form of *Triticites*

strongly suggests that the bulk of the Minnelusa Formation in the northern Black Hills is Permian in age. Although no marked physical stratigraphic break is evident between Pennsylvanian and Permian deposits, a tentative boundary is drawn in Bear Butte Canyon between a lower predominately carbonate sequence and the first massive sandstone that occurs in the section. This boundary is approximately 30 feet below the fusulinid zone. A fusulinid fauna has not been described from the northwestern Black Hills, but correlation of a fossiliferous zone in the lower 260 feet of the formation indicates that the section in Sand Creek Canyon (where Sand Creek crosses east line of T. 52 N., R. 61 W., Crook Co., Wyoming) is comparable to the Bear Butte Canyon section in age. Furthermore, a comparison of the two sections indicates their lithologies to be very closely similar. Although Brady (1931) suggested a Missouri-Virgil age for the upper beds of the Minnelusa in the northwestern Hills, an inspection of the reported fauna indicates no truly diagnostic forms. Virtually all forms have a long ranging character and have been reported from the Permian.

The basal 100 feet of the formation in Bear Butte Canyon is considered to be Pennsylvanian in age and units of the Atoka, Des Moines, Missouri, and Virgil series may be present. The red shale which overlies the Pahasapa and is the basal unit of the Minnelusa is determined to be middle Pennsylvanian in age on the basis of contained fossils in the southern Hills. Although it varies in thickness and perhaps age, it appears to be present around the entire Black Hills outcrop. Agatson (1954) states that it is absent in wells to the north of the Black Hills and is very thin on the east flank of the Powder River Basin. Dillé (1930) considered this unit to belong to the Des Moines series. Bates (1955) correlated the basal shale with the Fairbanks Formation of the Hartville region. Love, Henbest, & Denson (1953) concluded that the Fairbanks (Division VI of the Hartville section) "is probably of early Pennsylvanian or late Mississippian age." Love termed it "Pennsylvanian (?)" in 1954.

The presence of *Chaetetes milleporaceus*, as identified by Brady (1931), 90 feet above the base of the Minnelusa in Sand Creek Canyon indicates a possible Desmoinesian or Missourian age for these beds above the basal red shale. The presence of *Idiognathodus magnificus*, *Idiognathodus* aff. *I. claviformis*, and *Idiognathodus* aff. *I. acutus* 20 feet below the suggested Pennsylvanian-Permian boundary would suggest a Des Moines-Missouri age for these beds. The presence of *Gondollela* sp. suggests that the beds lying above the zone of *Chaetetes milleporaceus* may be assigned to the Missouri series. However, the genus *Gondollela*, while characteristically Missourian, has been reported from the Desmoinesian. Therefore, no conclusive evidence is available for assigning the beds directly below the Pennsylvanian-Permian contact as Missourian-Virgilian. No marked disconformity is apparent in the section. However, this does not define absence of these beds. It is suggested that beds of Missourian-Virgilian age may be present on the basis of the contained conodont assemblage and the possible upper Virgilian age of the *Triticites* fauna, but no conclusive proof is offered. If these two series are present, they must be very thin.

Southern Black Hills.—The Minnelusa Formation of the southern Hills ranges from approximately 450 to 700 feet in thickness. In general the formation can be divided into four or five lithologic units. A basal red sandy shale lies unconformably on the Pahasapa Limetone. Above this lies a limestone-shale sequence which is well developed near Loring Siding but is considerably thinner in other areas. A change to a dolomite-shale sequence is noted in the next overlying unit. This interval is quite well marked for a development of black shales which serve as excellent marker beds for correlation. Above this sequence lies a well developed red shale ranging in thickness from 12 to 21 feet. This bed is well developed in Red Canyon and Hot Brook Canyon on the southern flank and Rapid Canyon on the eastern flank of the Hills. The uppermost unit is a series of massive sandstones and some few beds of limestone and dolomite. The latter is severely brecciated in some localities. At the top of this unit lies a series

of beds which seem to be transitional between the overlying Opeche Shale and the underlying Minnelusa sandstone. The author considers these beds to be included in the Minnelusa, and the Minnelusa-Opeche contact is drawn between the change from a predominantly sandy sequence to a predominantly shaly sequence.

Fossils are very abundant in the lower portion of the formation, and, as a consequence, faunal zonation is regarded as quite concise. However, as in the northern Hills, the middle and upper beds offer little paleontologic evidence upon which to base age determinations.

The author in working in the Loring Siding area, sec. 4, T. 6 S., R. 4 E. and secs. 27 and 34, T. 5 S., R. 4 E., Custer County, recognized the fossiliferous horizon established by Dillé (1930) and the fusulinid zones as described by Thompson (1936). In addition, two additional fusulinid zones were sampled and analyzed by the author. The forms *Fusulinella furnishi* and *F. acuminata* were recognized. The two new zones, coupled with those previously established by Thompson, make a total of four fusulinid zones in the basal units of the Minnelusa of the southern Hills. These zones occur 85, 150, 155, and 170 feet respectively above the base of the formation.

A conodont fauna is described from a shale unit of the formation in Beaver Creek Canyon, secs. 29, 30, and 32, T. 5 S., R. 6 E., Custer County, South Dakota. The unit occurs approximately 225 feet above the base in this area. This same zone occurs in Hot Brook Canyon, west of Hot Springs, secs. 15 and 16, T. 7 S., R. 5 E., Fall River County, South Dakota, and can be correlated lithologically. However, no conodonts were found in this latter locality. The forms *Streptognathodus simulator*, *S. eccentricus*, *S. oppletus*, and *S. elegantulus* were recognized. *S. simulator* has been reported from the upper Missourian and through the middle Virgilian of Kansas and Missouri plus an isolated occurrence in the Permian Big Blue. It has also been reported from western Illinois in rocks of upper Desmoinesian age. *S. eccentricus* has been reported from the Bronson, Kansas City, and Lansing groups of Kansas and Missouri and is considered to be middle Missourian in age. *S. oppletus* appears to have a long stratigraphic range and has been reported from the Desmoinesian series of western Illinois, and from the Desmoinesian and Missourian series of Kansas and Missouri. *S. elegantulus* occurs sparingly in the Desmoinesian, abundantly in the Missourian, and is the dominant species of the Virgilian.

The Minnelusa Formation in the southern Hills is considered to contain both Pennsylvanian and Permian deposits. Faunal evidence is lacking in the upper part of the formation, but it seems that Permian beds are thinner than in the northern Hills. The basal 220 feet of the formation in the Loring Siding-Hot Springs area is considered to be Atokan in age on the basis of fossils from the basal shales and the fusulinid faunal zones near Loring Siding. Further east in Beaver Creek Canyon, the fossiliferous limestone-shale sequence is considerably thinner and only the basal 50 feet is considered to be Atokan in age. No distinct boundary exists between Atokan and Desmoinesian deposits. Condra, Reed & Scherer (1940) place a boundary between their Hayden and Roundtop groups on the change from a dominantly limestone-shale sequence to a dolomite-black shale sequence. This break occurs approximately 35 feet above the highest fusulinid zone in the Loring Siding area. The overlying 110 feet are considered to be Desmoinesian in age. This predominatly dolomite-shale sequence is unfossiliferous in the Hot Brook Canyon section. Near the top of this division in Beaver Creek Canyon there is a localized bed containing a gastropod and pelecypod fauna. However, the fossils are poorly preserved and, where identifications are possible, nondiagnostic. The form *Myalina cuneiformis*, reported by Work (1931), is characteristic of Des Moines deposits. The next significant faunal horizon is the conodont-bearing zone described in this paper. Immediately below this zone lies a slight hiatus. The conodont fauna lying immediately above the hiatus suggests a Missourian age. Above the suggested Des Moines-Missouri contact approximately 360 feet of a varying sequence of limestones, sandstones, dolomites and shales occur. Faunal zones are completely

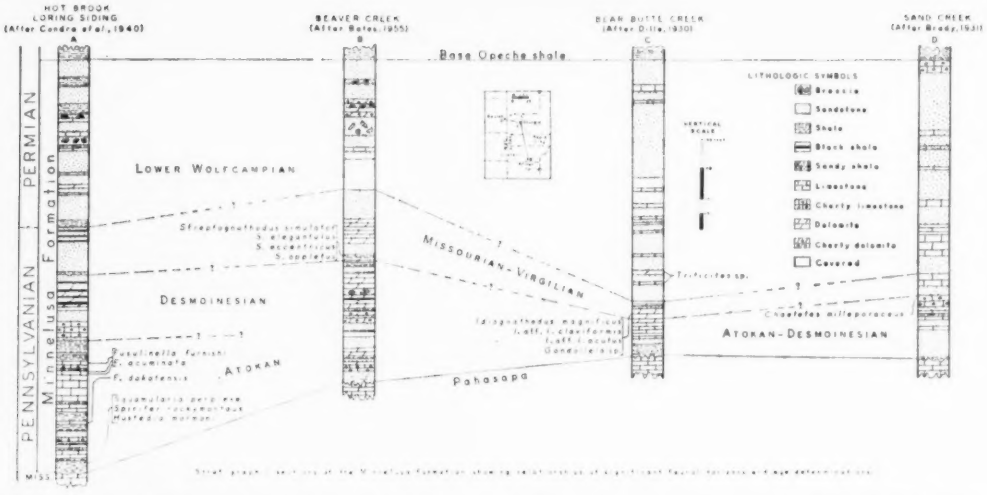
lacking. Work (1931) reports one fossiliferous horizon near the top of the formation in Hot Brook Canyon (Darton's upper fossiliferous horizon) but the fossils are not diagnostic. No attempt is made in this paper to differentiate beds of Missouri age from beds of Virgil age (if present). Condra *et al.* (1940) grouped the lower 210 feet of this sequence under their Wendover and Meek groups (Division II and III, Hartville nomenclature) and considered them to be Missourian and Virgilian in age.

Two unconformities were recognized by Condra *et al.* (1940) in the upper 150 feet of the formation. The uppermost lies 92 feet below the Minnelusa-Opeche contact, and the lower lies 122 feet below the Minnelusa-Opeche contact. However, they do not place their Pennsylvanian-Permian contact at either break. Instead it is placed 150 feet below the Minnelusa-Opeche contact between a limestone-sandstone sequence and a thin shale sequence. This writer suggests that the Pennsylvanian-Permian boundary may be another 140 feet lower in the section at the base of a prominent red shale. Bates (1955) discusses a thin red shale which occurs in subsurface 175 feet below the "First and Second Converse sands" in the Lance Creek area of the Powder River Bain. This thin red shale is called the "Red Marker" and marks the base of the upper anhydrite-sandstone section and the top of the middle dolomite-sandstone section. This horizon is recognized in subsurface for many miles away from Lance Creek. Bates states, however, that the horizon was not recognized in surface sections. Bates studied the Minnelusa outcrop in Beaver Creek Canyon and did not report the occurrence of a red shale in the upper part of the formation. About 50 feet of the section is unexposed and the author believes it may exist in this covered zone. A prominent red shale was recognized by the author in Hot Brook Canyon. In addition, a prominent red shale occurs 200 feet below the top of the Minnelusa in Rapid Canyon on the east flank and in Red Canyon on the southwest flank of the Black Hills. The upper beds of the Hot Brook Canyon section and the Beaver Creek Canyon section are closely similar in many respects and a correlation between the two shows that the red shale should be present. In Hot Brook and Rapid Canyons, the shale separates a predominantly dolomite-shale sequence from a sandstone-dolomite sequence. Therefore, it is considered by this author that the red shale may be correlative with the subsurface "Red Marker" of the Powder River Basin and that the shale marks the base of the Permian in the southern Hills.

CORRELATIONS

The evidence at hand indicates that the northern and southern Hills deposits of the Minnelusa are not even grossly correlative on interval alone. In addition, individual fossiliferous horizons are not consistent between the two ares. However, faunal age determinations from both areas can be correlated with reasonable certainty. The Pennsylvanian interval, which is quite well developed in the Loring Siding-Hot Brook Canyon area, appears to thin toward the north and east. The basal shale is consistent in outcrop around the flank of the Hills, but the well developed early Pennsylvanian fossiliferous limestone-shale sequence and the overlying black shale-dolomite sequence appears only in the southern Hills. The thinning of Pennsylvanian deposits toward the north is accompanied by a thickening of the Permian beds to a maximum development in the Bear Butte Canyon section. The massive sands of the Permian in the northern Hills grade westward into an evaporite sequence on the east flank of the Powder River Basin. To the south they are replaced by carbonate and sandstone breccias. These breccias have been interpreted to represent removal of anhydrite in place, and reworking of the the associated beds (Baker, 1947; Bates, 1955). Presumably most of the removal of evaporites was done by ground water after deposition (Bates, 1955). The breccias of the southern Hills, the massive sands of the northern Hills, and the evaporites of the northwestern Hills are considered to be correlative. A suggested correlation, based mainly on faunal age determinations of the Minnelusa outcrop is illustrated (Text-fig. 1).

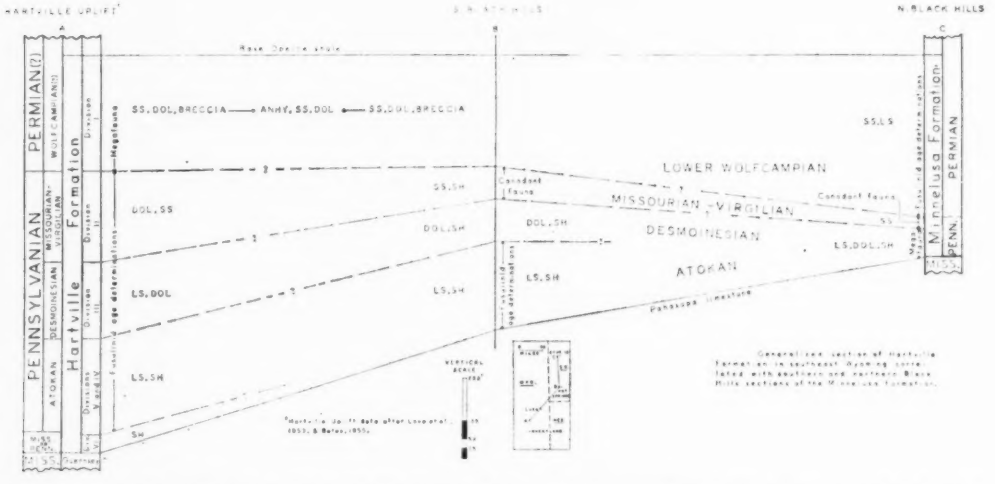
The purpose of the following discussion is to relate the Pennsylvanian and lower Perm-



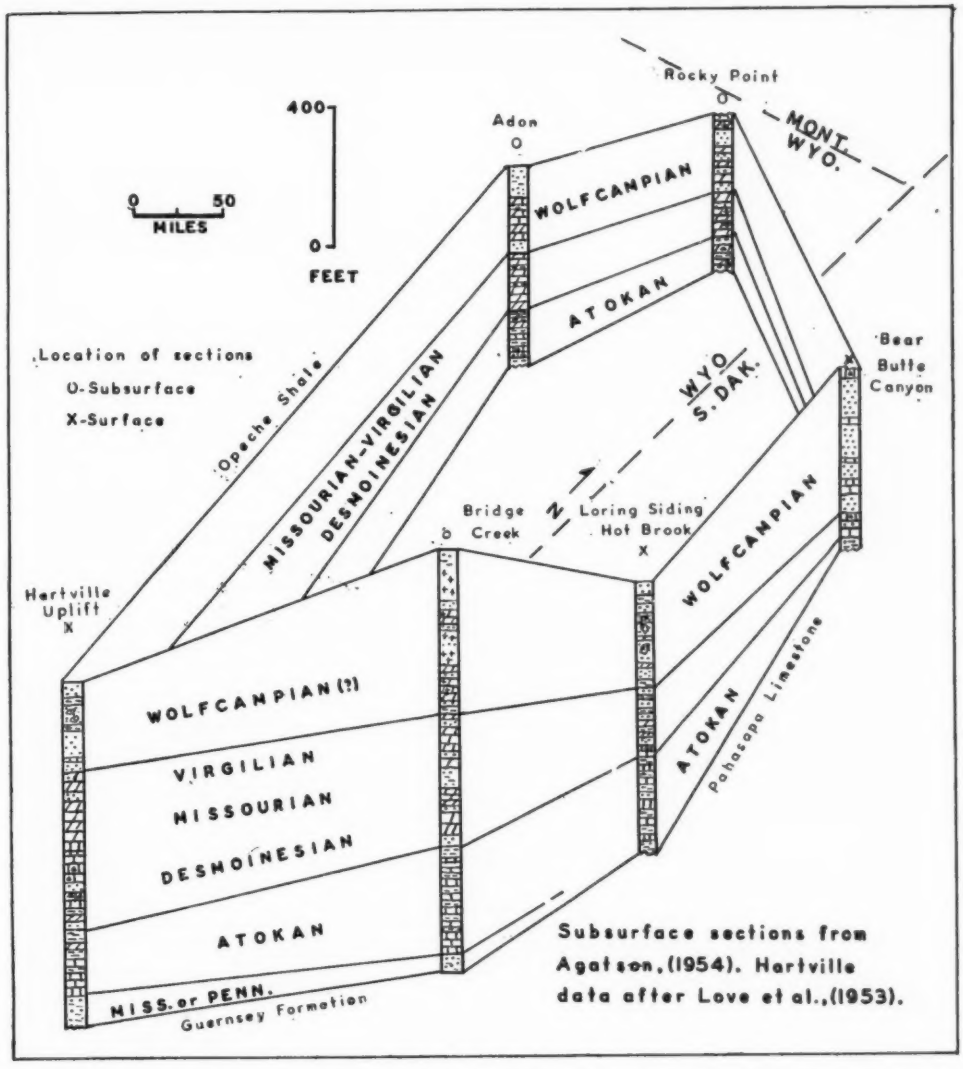
TEXT-FIG. *1*—Stratigraphic sections of the Minnelusa Formation showing relationships of significant faunal horizons and age determinations.

ian Minnelusa sections of the Black Hills with surrounding areas. As a basis, reference is made to Text-figure 2, a correlation from the surface Minnelusa with the surface Hartville, and to Text-figure 3, a panel diagram of these systems for the eastern flank of the Powder River Basin and for the Black Hills.

Love, Henbest, & Denson (1953) published a comprehensive report of the paleontology and stratigraphy of the Hartville Formation in the Hartville Uplift. A modified version of the earlier six fold division was utilized, in which Divisions IV and V were mapped as a unit. Diagnostic fusulinid faunas were listed from Division II through V, and time boundaries were suggested. Division VI was found to be unfossiliferous but was considered to be late Mississippian or early Pennsylvanian in age on its rela-



TEXT-FIG. *2*—Generalized section of Hartville Formation in southeast Wyomng correlated with southern and northern Black Hills sections of the Minnelusa Formation.



TEXT-FIG. 3—Panel diagram showing correlation of surface Minnelusa, Black Hills; subsurface Minnelusa. Powder River Basin; and surface Hartville, Hartville Uplift.

tionship with the underlying Guernsey Formation. Division I, the sandstone breccia part of the Hartville, was considered to be Wolfcampian (?) in age on its relationship with surrounding areas. No diagnostic fossils were obtained from Division I. Textfigure 2 is a suggested correlation of the surface Hartville with the surface Minnelusa of the Black Hills. Although individual fossiliferous horizons cannot be correlated between the two areas, the paleontological evidence as presented in this paper together with the lithologic similarities of the two areas indicate they are correlative.

Bates (1955) in his study of the Permo-Pennsylvanian formations of Wyoming and South Dakota states, "The terms Minnelusa and Hartville actually apply to three different lithologic combinations: (1) full section present—subsurface Minnelusa; (2)

full lower section present but breccias instead of evaporites in the upper part—Hartville formation; (3) lower limestone-shale section thin and upper evaporites replaced by breccias—surface Minnelusa." Bates correlates the brecciated upper Minnelusa in the Beaver Creek area with the upper evaporite zone in the subsurface Minnelusa and this in turn with the upper Hartville (Division I). The author concurs with this viewpoint. Furthermore, if the red shale occurring in the upper Minnelusa of the southern and eastern Hills is correlative with the "Red Marker" zone of the Lance Creek area, as has been suggested by this study, the Pennsylvanian-Permian contact can be correlated from the Black Hills outcrop into the subsurface Minnelusa of the Powder River Basin. The "Red Marker" has been recognized in the subsurface as the base of the Permian (Agatson, 1954). Agatson traces units of the subsurface Hartville north from the Bridge Creek section into the subsurface Minnelusa and recognized the Hartville divisions as far north as Rocky Point, Wyoming (Agatson, 1954). These data have been incorporated and a correlation made eastward to the Bear Butte Canyon surface section of the Black Hills (Text-fig. 3).

The presence of lower Permian fusulinids in the upper Minnelusa of the northern Black Hills indicates that it is correlative both on a lithologic and paleontologic basis with the upper Tensleep of the east flank of the southern Big Horn mountains. Verville (1957) reports Wolfcampian *Triticites* and *Schwagerina* near the top of the formation near Mayoworth, Wyoming. Verville correlates the Tensleep in the southern Big Horn mountains with most of the Casper Formation in the Laramie Range and with Divisions I, II, and III, and the upper part of combined Divisions IV and V of the Hartville Formation. These units, in turn, appear correlative with the Minnelusa of the Black Hills.

SYSTEMATIC DESCRIPTIONS

Genus STREPTOGNATHODUS Stauffer & Plummer 1932

STREPTOGNATHODUS OPPLETUS Ellison

Pl. 124, fig. 8

Streptognathodus oppletus ELLISON, 1941, Jour. Paleontology, v. 15, p. 132; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, Art 3, p. 192.

In oral view, outline of platform long, very slender, symmetrical, lanceolate, posteriorly pointed, with greatest width near anterior one-third; accessory lobe inner side only, surface of lobe nodose, consisting of 3 nodes; transverse section flat to slightly concave; oral surface ornamented with 11 parallel transverse ridges extending across a poorly developed median oral trough and against a well developed carina.

Blade consists of 13 denticles continued posteriorly as a carina for one-half the length of the platform; sulci on both sides of the carina continue and merge posteriorly with the median trough.

Remarks.—Streptognathodus oppletus does not show clearly the characteristics of the genus due to the nature of the median trough and the character of the transverse ridges. Most species of *Streptognathodus* have a more well developed oral trough and the transverse ridges do not continue across the trough. However, the form considered here closely resembles the holotype as described by Ellison.

Occurrence.—Streptognathodus oppletus occurs in association with *S. eccentricus*, *S. elegantulus*, and *S. simulator* in a shale unit of the Minneulsa Formation in Beaver Creek Canyon. The zone lies approximately 225 feet above the base of the formation in this locality.

STREPTOGNATHODUS SIMULATOR Ellison

Pl. 124, fig. 7

Streptognathodus simulator ELLISON, 1941, Jour. Paleontology, v. 15, p. 133; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, Art 3, p. 192.

Oral view of platform long, slender, lanceolate, asymmetrical, posteriorly pointed to slightly rounded, greatest width near anterior one-third; accessory lobe on inner side only; surface of lobe nodose or nodose and ridged, with 5–6 nodes; oral surface bears a very shallow, slightly flexed trough offset from the median line toward the inner side; oral surface ornamented with 9 to 14 transverse ridges ending both gradually and abruptly in the oral trough with some of the transverse ridges in the anterior

portion of the platform slightly bridging the trough; blade consists of 10 denticles continued as a carina on the anterior one-third of the platform; carina ends abruptly in the oral trough against a transverse ridge and is set off from the lateral margins of the platform by moderately deep sulci; sulcus on inner side continues as oral trough.

Remarks.—The specimens studied are closely similar to the holotype as described by Ellison. The oral trough appears to be shallower and the apron is not flared to as great a degree.

Occurrence.—*Streptognathodus simulator* occurs sparingly in a shale unit of the Beaver Creek Canyon section of the Minnelusa Formation about 225 feet above the base. *S. simulator* occurs in association with *S. eccentricus*, *S. elegantulus*, and *S. oppletus*.

STREPTOGNATHODUS ELEGANTULUS
Stauffer & Plummer
Pl. 124, fig. 6

Streptognathodus elegantulus STAUFFER & PLUMMER, 1932, Univ. Texas Bull. 3201, Contr. to Geol., Pt. 1, p. 47, pl. 4; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, Art. 3, p. 191.

Outline of platform in oral view long, slender, slightly curved, sublanceolate, posteriorly pointed, greatest width near anterior one-third; no accessory lobes; transverse section of oral surface deeply concave with a U-shaped median trough extending the entire length of the platform, single longitudinal nodose ridges extend the full length of the platform along the outer margins of the oral surface.

Blade broken, extension of blade as prominent carina extending through the anterior one-fourth of the median trough, end of carina marked by large bulbous node; carina set off from platform on either side by sulci that merge posteriorly into the median trough.

Remarks.—The specimen described is very closely similar to a hypotype described by Ellison. A comparison with figures of the holotype and paratypes of Stauffer & Plummer indicate that the median trough appears somewhat wider and the carina does not extend as far posteriorly in the specimen described in this paper. However, the relationship between the two appears to be very close.

Occurrence.—*Streptognathodus elegantulus* occurs in a shale unit of the Minnelusa Formation in Beaver Creek Canyon, approximately 225 feet above the base of the formation. It occurs in conjunction with *S. oppletus*, *S. eccentricus*, and *S. simulator*.

STREPTOGNATHODUS ECCENTRICUS Ellison
Pl. 124, fig. 9

Streptognathodus eccentricus ELLISON, 1941, Jour. Paleontology, v. 15, p. 132; FAY, 1952, Univ. of Kansas Paleont. Contr., Vertebrata, Art 3, p. 191.

Oral view of platform long, lanceolate, asymmetrical, posteriorly pointed, greatest width near anterior one-fourth; accessory lobes on both sides of platform, inner more well developed and set off distinctly by a ridge from main body of platform, surface of lobes nodose, consisting of 7 to 9 nodes; oral surface bears a straight longitudinal trough offset from the median line toward the inner side; oral surface ornamented with 10 to 12 transverse ridges ending abruptly in the trough.

Blade relatively moderate in length, consisting of 9 denticles, continued as a carina only slightly on the anterior end of the platform. Carina ends abruptly against a transverse ridge and is set off from the platform by sulci. Sulcus on inner side continues as oral trough.

Remarks.—*Streptognathodus eccentricus* is characterized by the position of the accessory lobes to the anterior of the platform proper. The only observed difference between *S. simulator* and *S. eccentricus* is the development of an outer accessory lobe on the latter. Also, *S. eccentricus* in the specimens studied, has a more widely flared apron beneath the platform.

Occurrence.—*Streptognathodus eccentricus* occurs associated with *S. simulator*. *S. elegantulus*, and *S. oppletus* in the Beaver Creek Canyon section of the Minnelusa Formation.

Genus IDIOGNATHODUS Gunnell 1931
IDIOGNATHODUS aff. I. CLAVIFORMIS Gunnell
Pl. 124, figs. 4,5

Idiognathodus claviformis GUNNELL, 1931, Jour. Paleontology, v. 5, p. 249–251; FAY, 1952,

Univ. Kansas Paleont. Contr., Vertebrata, Art. 3, p. 112.

Outline of platform in oral view broad, stout, posteriorly pointed to blunted, greatest width near anterior one-third of platform; well developed accessory lobe on inner side, poorly developed outer lobe; surface of lobes nodose; transverse section of surface nearly flat, oral surface ornamented with 6 to 8 essentially parallel discontinuous ridges.

Blade broken, continues posteriorly into the anterior one-third of the platform as a curved aborted carina; carina set off from the anterior portion of the platform by sulci.

Remarks.—The specimen described bears slight resemblance to the form described by Gunnell. However, under the redefinition of the form by Ellison, this specimen appears related to *Idiognathodus claviformis* on the basis of its stout appearance and discontinuous ridges across the oral surface. Aside from the partially discontinuous ridges, its general appearance approaches that of the form described as *I. magnificus* in this paper. Observations are based on only a few broken specimens not of sufficient number to attempt definitive species determinations.

Occurrence.—The species described occurs associated with *Idiognathodus* aff. *I. acutus*, *I. magnificus*, and *Gondollela* sp. in a thin shale in Vanocker Canyon, approximately 75 feet above the base of the Minnelusa Formation in the northern Black Hills.

IDIOGNATHODUS aff. I. ACUTUS Ellison
Pl. 124, fig. 3

Idiognathodus acutus ELLISON, 1941, Jour. Paleontology, v. 15, p. 137; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, Art. 3, p. 111.

Outline of platform wedge-shaped, in oral view, acutely pointed posteriorly, greatest width near anterior one-third; accessory lobes on both sides of platform, inner larger, outer not distinctly set off from main body of platform, surface of lobes nodose; transverse section of oral surface slightly concave, oral surface ornamented with nodes along outer margins of platform, grading into indistinct parallel ridges which are discontinuous from one margin to the other.

Blade broken, continues posteriorly into the anterior one-fourth of the platform as a carina; carina set off from the anterior portion of the platform by sulci.

Remarks.—The discontinuous parallel ridges are quite characteristic of *Idiognathodus claviformis*. However the acutely pointed nature of the platform indicates close affinities with *I. acutus*.

Occurrence.—*Idiognathodus* aff. *I. acutus* occurs in conjunction with *Idiognathodus* aff. *I. claviformis*, *I. magnificus*, and *Gondollela* sp. in Vanocker Canyon, 75 feet above the base of the Minnelusa Formation.

IDIOGNATHODUS MAGNIFICUS Stauffer & Plummer
Pl. 124, figs. 1,2

Idiognathodus magnificus, STAUFFER & PLUMMER, 1932, Univ. Texas Bull. 3201, Contr. to Geol., pt. 1, p. 46–47; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, Art. 3, p. 113.

Outline of platform in oral view long, lanceolate, and posteriorly pointed, greatest width near anterior one-third of platform; accessory lobes on both sides of platform, inner more well developed, surface of lobes both nodose and ridged; transverse section of oral surface nearly flat to slightly concave upward, platform ornamented with 7 to 9 parallel transverse ridges which are continuous from the margins.

Blade relatively long, terminated at right angles anteriorly, 8 to 10 denticles continued posteriorly into the anterior one-third of the platform as a carina; carina set off from platform by deep sulci which cause the anterior portion of the platform to extend as free edges.

Remarks.—The described form is very closely similar to those described by Ellison. In several specimens observed, the ornamentation on the accessory lobes was quite varied ranging from entirely nodose to entirely ridged.

Occurrence.—Abundant specimens of *Idiognathodus magnificus* occur in conjunction with *Idiognathodus* aff. *I. claviformis*, *I.* aff. *I. acutus*, and *Gondollela* sp. about 75 feet above the base of the Minnelusa Formation in Vanocker Canyon.

Genus GONDOLLELA Stauffer & Plummer 1932

GONDOLLELA sp.
Pl. 124, figs. 10,11

Platform elongate, boat shaped, sublanceolate, tapered anteriorly toward the carina, anterior one-fourth of platform has parallel sides, greatest width near posterior one-fourth; oral surface concave upward, ornamented by low transverse sharp crested branching ridges slightly oriented toward the posterior of the platform, transverse ridges obsolescent toward the carina.

Carina low, moderately crenulate, consisting of 10 compressed both coalesced and separate denticles; two posterior cusps present separated from the carina by a concave depression, cusps directed slightly toward the posterior of the platform.

Aboral surface of platform smooth and undulating; keel narrow, uniformly tapered to an anterior point; loop asymmetrical with somewhat more lateral extension on one side.

Remarks.—This form species does not appear closely related to any previously described species of the genus *Gondollela*. However, specimens are not common enough to attempt erection of a new taxon.

Occurrence.—*Gondollela* sp. appears associated with the species of *Idiognathodus* from Vanocker Canyon in the northern Black Hills.

Family FUSULINIDAE Möller, 1878
Subfamily SCHWAGERININAE Dunbar & Henbest 1930
Genus TRITICITES Girty 1904
TRITICITES sp. A
Pl. 124, figs. 12-14

The shell of this species is of medium size, inflated fusiform, with steep concave to straight lateral slopes and pointed to slightly

TABLE 1—Measurements of *Triticites* sp. *A* & *B* (Specimen 16 only B), in Millimeters

Specimen	L.	W.	Ratio	Diam. of prol.	Height of volutions						
					1	2	3	4	5	6	7
1	4.0	2.3	1.8	.186	.046	.095	.115	.150	.210	.224	.245
2	—	—	—	—	—	—	—	—	—	—	—
3	3.9	2.0	1.9	.188	—	—	—	—	—	—	—
4	—	—	—	.148	—	—	—	—	—	—	—
5	3.5	2.5	1.4	—	—	—	—	—	—	—	—
6	—	2.1	—	.188	—	—	—	—	—	—	—
7	3.5	2.0	1.7	—	—	—	—	—	—	—	—
8	—	—	—	.175	—	—	—	—	—	—	—
9	—	—	—	.150	—	—	—	—	—	—	—
10	—	—	—	.112	—	—	—	—	—	—	—
11	—	—	—	.100	—	—	—	—	—	—	—
12	—	2.1	—	.137	—	—	—	—	—	—	—
13	—	2.1	—	.167	.074	.111	.158	.204	.223	.279	
14	3.8	2.0	1.9	.148	.055	.070	.112	.180	.302		
15	3.6	2.1	1.6	.125	—	—	—	—	—	—	—
16	3.2	2.0	1.5	.074	—	—	—	—	—	—	—

Specimen	Thickness of spirotheca							Tunnel angle (degrees)					
	1	2	3	4	5	6	7	1	2	3	4	5	6
1	.025	—	.050	—	.110	.125	.112	—	14	16	19	23	17
3	—	—	—	—	.094	.100	—	—	—	—	—	—	—
4	—	—	—	—	—	.100	—	—	—	—	—	—	—
5	—	—	.050	.062	—	—	.088	—	—	21	27	29	38
10	—	.032	—	—	—	—	.100	—	—	—	—	—	—
13	.025	.027	.055	.074	.110	.090	—	—	—	—	—	—	—
14	—	—	—	.065	.093	—	—	—	14	18	23	22	—
15	—	—	—	—	.090	.120	.100	—	—	—	19	29	20
16	.018	.025	.028	.040	.043	.055	.046	—	—	22	26	21	—

blunted polar ends. Specimens of seven volutions range in size from 2.5 to 4.0 mm. in length and 2.0 to 2.5 mm. in width, giving form ratios of 1.4 to 2.0 in mature specimens. The general fusiform almost spherical shape is maintained through the inner volutions but as the fourth volution is approached, a slight elongation of the polar regions is noted which continues into the mature form.

The proloculus is of medium size with an outside diameter of 100 to 202 microns, an average of 150 microns for the twelve specimens. In the twelve specimens studied, the proloculus was spherical to subspherical in shape with two specimens showing an ellipsoidal development.

The spirotheca is thick and coarsely alveolar with the structure extending into the outside edges of the septa. Lamellae between the alveoli are about 7 microns in thickness and the individual alveoli from 14 to 17 microns in thickness. A slight epithecal development is noted over the tectum. The spirotheca increases in thickness to the sixth volution and then decreases in the last volution. Average thicknesses on six specimens in a composite tabulation from the first to seventh volution are 25, 32, 50, 62, 98, 111, and 100 microns, respectively.

The septa appear to be only slightly fluted across the center of the shell with accelerated fluting toward the polar regions extending gradually away from the axis.

The tunnel has a relatively straight path. Average tunnel angles in the second to sixth volutions of three specimens are 14, 18, 22, 27, and 25 degrees, respectively. The chomata appear massive and asymmetrical, having steep tunnel sides, rounded tops, and a low angle dip toward the poles.

Remarks.—A comparison of the *Triticites* sp. from Bear Butte Canyon with described Virgilian forms of *Triticites* indicate some general similarities in shape. However, this species appears more closely related to lower Wolfcampian forms by its thicker spirotheca, larger and more irregular proloculus, and more inflated shape. It resembles *T. californicus* Thompson & Hazzard, but its proloculus is smaller, tunnel more regular and narrower, and more massive chomata in the outer volutions. This form is similar in general appearance to *T. pinguis* Dunbar & Skinner, but has fewer volutions, smaller proloculus, and thinner spirotheca. The Black Hills *Triticites* appears closely similar to *Triticites ventricosus* (Meek & Hayden) in general form, proloculus size, thickness of spirotheca, thickness of proloculus wall, tunnel angle, and shape of chomata but is considerably smaller than most described individuals. However, it resembles strongly the short gibbous specimen of *Triticites ventricosus* reported from the Hughes Creek shale of Nebraska by Dunbar & Condra (1928). In Thompson's publication on American Wolfcampian fusulinids (1954), a specimen identified as *Triticites* sp. from the Hughes Creek Shale is closely similar to the form described except that the former is almost twice as large.

Occurrence.—The *Triticites* fauna occurs approximately 125 feet above the base of the Minnelusa Formation in Bear Butte Canyon in two thin beds of sandy dolomite. Specimens were found in two localities on the southwest limb of the Whitewood anticline, 100 feet above Bear Butte Creek. This same zone was also found in Vanocker Canyon and Little Elk Creek Canyon but specimens collected at those latter localities were too poorly preserved for description.

TRITICITES sp. B
Pl. 124, fig. 15

The specimen here referred to as *Triticites* sp. B is illustrated to show the variation in the Black Hills fauna. It appears to be similar in overall shell development to *Triticites* sp. A, but has a smaller proloculus and slightly thinner spirotheca.

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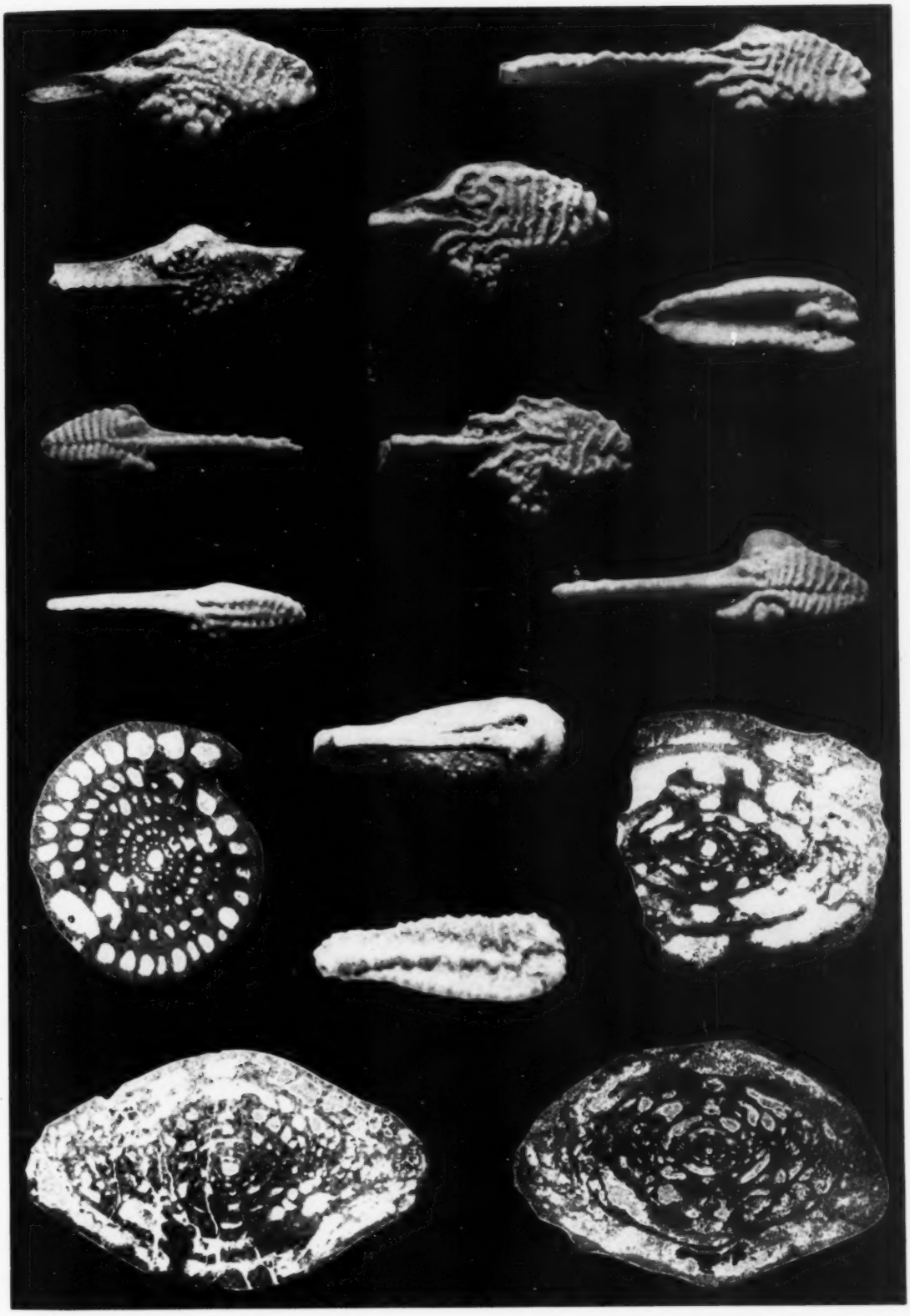
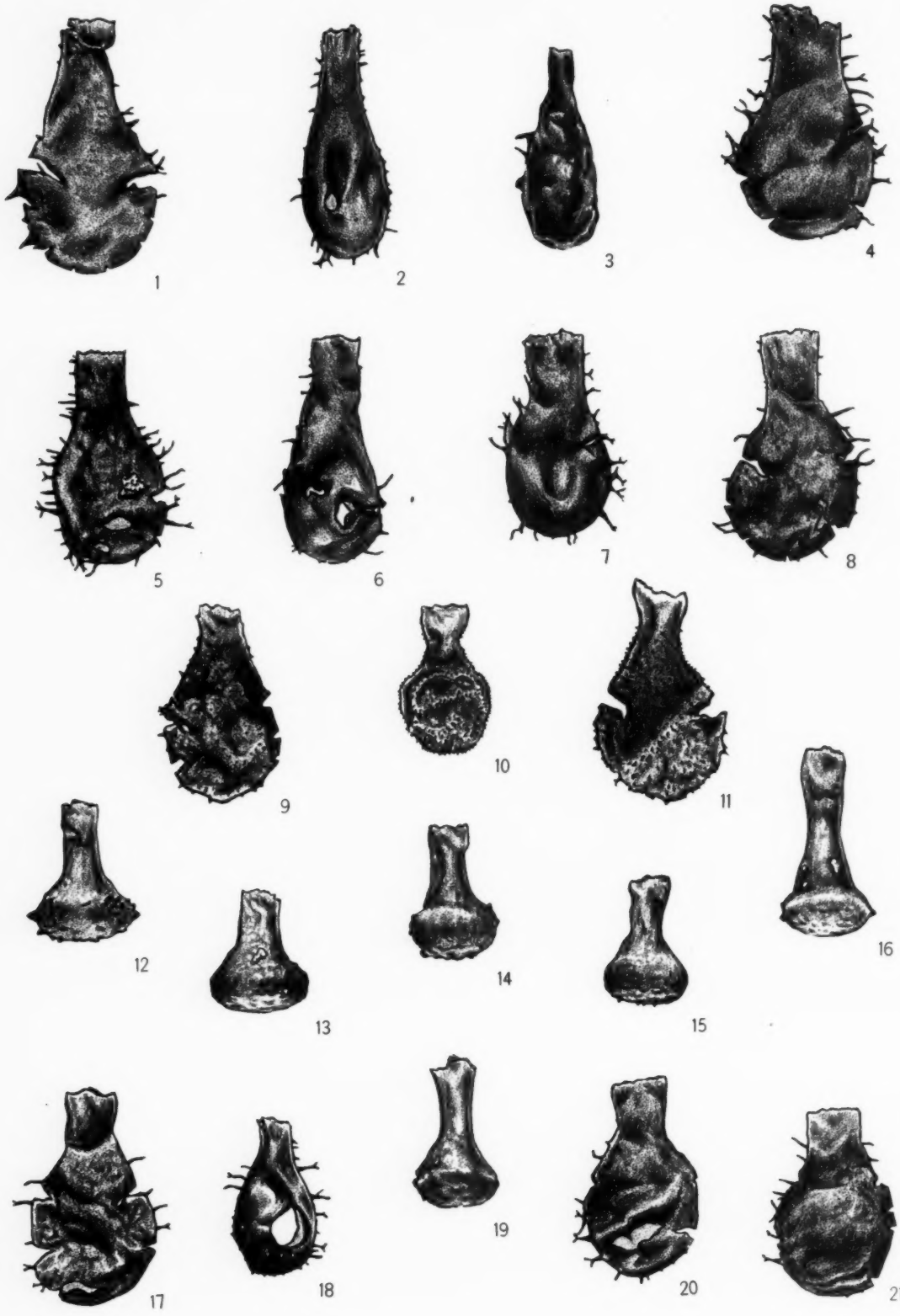
EXPLANATION OF PLATE 124

Specimens are from the Minnelusa Formation, Black Hills, South Dakota. All conodonts ×30. All fusulinids ×16.

FIG. *1,2—Idiognathodus magnificus* Stauffer & Plummer. Oral view. Vanocker Canyon. (S.U.I. 10154).
3—Idiognathodus aff. *I. acutus* Ellison. Oral view. Vanocker Canyon. (S.U.I. 10158).
4,5—Idiognathodus aff. *I. claviformis* Gunnell. Oral view. Vanocker Canyon. (S.U.I. 10151).
6—Streptognathodus elegantulus Stauffer & Plummer. Oral view. Beaver Creek Canyon. (S.U.I. 10153).
7—Streptognathodus simulator Ellison. Oral view. Beaver Creek Canyon. (S.U.I. 10157).
8—Streptognathodus oppletus Ellison. Oral view. Beaver Creek Canyon. (S.U.I. 10152).
9—Streptognathodus eccentricus Ellison. Oral view. Beaver Creek Canyon. (S.U.I. 10156).
10,11—Gondollela sp. *10*, Aboral view; *11*, oral view. Vanocker Canyon. (S.U.I. 10155).
12–14—Triticites sp. A. *12*, Sagittal section; *13*, *14*, axial sections. Bear Butte Canyon. (S.U.I. 10161, 10162, 10163).
15—Triticites sp. B. Axial section. Bear Butte Canyon. (S.U.I. 10163).

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DEVONIAN CHITINOZOANS FROM THE CEDAR VALLEY FORMATION IN IOWA

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ABSTRACT—Two new occurrences of some relatively little known microfossils are reported. These microfossils, called chitinozoans, are believed to represent an extinct order of rhizopod protozoans. The fauna described is that of the Devonian Cedar Valley formation, and represents a composite sampling of that unit from locations near Ottumwa, Iowa, and Coralville, Iowa. More than 14 species are described which are referable to the genera *Angochitina*, *Ancyrochitina*, *Sphaerochitina* and *Earlachitina*. Included in the fauna is one new species, *Sphaerochitina collinsoni*, and two species previously unreported from Devonian rocks.

Relationships with other Devonian faunas are discussed. It is concluded that an earlier reported occurrence of this fauna from the Solon member of the Cedar Valley is in error; evidence is presented indicating the source was from the Rapid member.

Information concerning the distribution, thickness, lithology, age, and correlations of the Cedar Valley formation is discussed in some detail.

Techniques of recovering chitinozoan specimens from limestone are reviewed.

INTRODUCTION

THE NATURE OF CHITINOZOANS

CHITINOZOANS were first reported by Einsenack from Ordovician and Silurian rocks of the East Prussia Baltic region in 1931. Since this time, knowledge concerning these microfossils has progressed rather slowly in Europe, and they have received little recognition from American paleontologists and stratigraphers (Collinson & Schwalb, 1955).

There is no certainty among paleontologists concerning the precise zoological affinities of these microfossils. For reasons discussed in their report, Collinson & Schwalb (1955) recognize Chitinozoa as an order under the class Rhizopoda of phylum Protozoa. The writer finds no reason to disagree. One of the most important factors to be considered in determining the affinities, according to them, is the composition of the material of the test. They point out that analyses by several people indicate the material is of a pseudochitinous nature—close to the composition of the shells of the Recent Thecamoeba *Gromia oviformis*, but not very close to true chitin. They further state (1955) that providing for "any changes of composition of the chitinozoan tests during preservation, an original composition of pseudochitin seems probable."

Chitinozoans thus far have been recovered primarily from limestone but have also been found in chert, dolomite, and shale (Collinson & Schwalb, 1955).

Prior to the Collinson & Schwalb report of 1955, only four references to chitinozoans were known in the geologic literature of North or South America. Stauffer (1933) reported the first occurrence in the western hemisphere from the Middle Ordovician Decorah formation of Minnesota. Cooper (1942) reported the known range of these microfossils in North America as being from the Ordovician to the Devonian; a single

EXPLANATION OF PLATE 125

All specimens from the Cedar Valley limestone near Ottumwa, or Coralville, Iowa, ×200.

FIG. *1,2,4–8—Angochitina devonica* Eisenack.
3—Angochitina cf. *A. devonica* Eisenack.
9–11—Angochitina mourai Lange.
12–16,19—Sphaerochitina nodulosa Collinson & Scott.
17,18,20,21—Angochitina milanensis Collinson & Scott.

species was reported by Lange (1949) from the Lower Devonian Ponta Grossa shale of Brazil, and three species were listed by Lange (1952) as occurring in the Middle Devonian Barreirinha shale, also of Brazil.

According to Collinson & Schwalb (1955), these microfossils have been used as stratigraphic markers by oil geologists of the Eastern Interior Basin and stratigraphers of the Illinois Geological Survey for some time, without their exact nature being known. The limits of the Devonian Clear Creek chert are defined by the presence of these "black spore-like bodies."

Collinson & Schwalb (1955) consider that these microfossils may prove to be quite valuable for correlation in both outcrops and the subsurface. They point out several characteristics which support this conclusion: (1) their widespread geographic occurrence, (2) the virtually indestructible material of which they are composed, (3) their easy recognizability in outcrop and well samples, and (4) the fact that they are small enough, with enough recognizable characteristics, to be identified in fine well cuttings. It must be emphasized, however, that considerable research remains to be done before their value is proven.

THE CEDAR VALLEY LIMESTONE

Distribution.—The Cedar Valley Limestone is the most widespread of the Devonian formations in Iowa. It extends from southern Minnesota 225 miles southeastward to Rock Island County, Illinois. It crops out in a belt 75 miles wide at the north and 20 miles wide at the south. A geologic map of Iowa (1937) shows the following counties to have Cedar Valley entirely or in part as their country rock: Howard, Mitchell, Floyd, Chichasaw, Butler, Bremer, Fayette, Black Hawk, Buchanan, Benton, Linn, Johnson, Cedar, Muscatine, and Scott. Counties adjacent to these have smaller areas of Cedar Valley. Beneath the surface the Cedar Valley appears to extend into most of the south, central, and western portions of the state; also into Nebraska, Kansas, northern Missouri, and west-central Illinois (Stainbrook, 1944).

Thickness.—According to Stainbrook (1935), the average thickness of the Cedar Valley limestone is more than 100 feet but varies from place to place, owing partly to erosion, and partly to thinning of beds; local diastems may also be a reason. The maximum thickness of 140–150 feet is found in the area of Buchanan and Benton counties. In Johnson County the thickness is about 120 feet, and in the Davenport-Muscatine region the thickness totals about 90 feet. Scobey (1938) and those who support the cave-filling origin of the underlying Independence shale, hold the Cedar Valley to lie conformably upon the Davenport member of the Wapsipinicon formation. The Cedar Valley overlaps the Silurian and Ordovician to the north.

Lithology.—The Cedar Valley formation is almost entirely limestone; some layers are composed of an aggregate of corals or crinoids and fragments of brachiopod shells. Some portions, especially near the top, are lithographic in texture; others are subdolomitic or shaly. In the northern part of the exposed area secondary dolomitization is common (Stainbrook, 1944). The threefold division of this stratigraphic unit is based primarily on the megafossils.

Solon member: The type locality of this member is an abandoned quarry on the west edge of the town of Solon, on the north side of the road, sec. 24, T. 81 N., R. 6 W. Lithologically the Solon is variable. The basal beds are in most cases massive, dense, tough, resistant, and gray to grayish-brown in color. Included in the basal member is the "Upper Davenport" or *Atrypa independensis* zone. The intermediate beds are characteristically quite argillaceous, relatively thin-bedded, less resistant, drab in color, but can be distinguished by the greater number of fossils which occur. The upper beds are dense, tough, resistant, gray, and bear the coral *Hexagonaria profunda* (Stainbrook) in great numbers. At Linwood, in Scott County, the member is from 8 to 12 feet thick; it is 20 feet thick in Johnson County; and in the area of Benton and Buchanan counties, attains a maximum thickness of 50 feet (Stainbrook, 1935).

Rapid member.—This member takes its name from Rapid Creek in Johnson County where there are natural exposures along the creek in sections 34, 35, and 36 of T. 80 N., R. 6 W., 2 or 3 miles north of Iowa City in central Johnson County. The lithology of

this member also varies in different localities. Although a shaly and argillaceous nature may predominate in some regions, the member is mostly limestone. The basal beds are gray in color, relatively soft, and contain abundant fossils, *Atrypa bellula* Stainbrook being the characteristic brachiopod and marker for the base of the Rapid. Other fossils characteristic of these lower strata are *Stropheodonta halli* Cleland, *Elytha subundiferus* (M. & W.), *Spirifer cedarensis* Owen, and others (Stainbrook, 1941). The middle beds are more calcareous, denser, and massively bedded. They are known as the Pentamerella beds, the marker fossils being *Pentamerella magna* Stainbrook and *Pentamerella rugosa* Stainbrook. Also characteristic is a widespread coral biostrome in which the chief coral is *Prismatophyllum cedarensis* Stainbrook (Stainbrook, 1941). The upper beds consist of a bluish-gray limestone which weathers to buff; it is relatively resistant but in some cases forms a yellow geest (Stainbrook, 1935). These uppermost beds, including the geest or "yellow shales" of Calvin are extremely fossiliferous with *Atrypa waterlooensis* Webster being the marker. *Strobilocystites calvini* White, *Megistocrinus pernodosus* Thomas, *Stereocrinus harberti* Stainbrook, and other fossils also occur here. Thickness varies from 21 feet at Littleton to 67 feet in the Buffalo-Linwood region. It is 35 feet thick in Johnson County.

Coralville member.—This member is named for the exposures found in the quarries about a mile northeast of Coralville in sec. 33, T. 80 N., R. 6 W., in central Johnson County, Iowa, which is now being worked by the River Products Company. Extensive quarry operations have resulted in good exposures of the Coralville and Rapid members.

The Coralville member is entirely limestone, predominantly lithographic but in places dolomitic, and gray to white in color. In the Cedar Valley outcrop area to the southeast the basal beds are argillaceous and coraliferous, while the upper part is usually dolomitized (Stainbrook, 1935). The basal beds are characterized by *Cranaena iowensis* Calvin, *Stropheodonta plicata* Hall, *Atrypa rotunda* Stainbrook, and *Prismatophyllum thomasi* Stainbrook. Locally, an upper coral biostrome is formed by large and numerous individuals of the latter type. The middle layers of the Coralville member bear great numbers of *Stromatopora* and *Idiostroma*, and form the *Stromatopora* zone. *Straparollus* is found in the uppermost beds, forming the *Straparollus* zone (Stainbrook, 1941). The Coralville member varies in thickness from 12 feet in Muscatine County to 40 feet near Garrison in Benton County. It is 38 feet thick at the type locality in Johnson County (Stainbrook, 1935).

AGE AND CORRELATIONS OF THE CEDAR VALLEY LIMESTONE

Age.—Investigators are not in agreement concerning the age of the Cedar Valley limestone. Weller (1909) and Thomas (1924) correlated it with the Upper Devonian Tully formation of New York owing to the presence of *Hypothyridina* in the lower part. Stainbrook (1935) considered the Cedar Valley to be late Devonian because a Chemung fauna, the Independence fauna, was found beneath it.

The supposed basal Upper Devonian position of *Hypothyridina* has been virtually undisputed in this country, and has been used as conclusive evidence in this respect. However, it actually occurs well down in the Middle Devonian in Europe and Asia; therefore its mere occurrence does not signify an Upper Devonian age (Cooper & Warthin, 1942).

According to Cooper & Warthin (1942) the known fauna of the Cedar Valley contains no fossils entirely restricted to the late Devonian. Besides the fact that late Devonian guides are absent, most of the genera are those most commonly found in Tully and Onondaga rocks such as *Pentamerella*, *Leptostrophia*, *Stropheodonta*, *Stereocrinus*, *Megistocrinus*, *Pentremitidea*, *Nucleocrinus*, and *Prismatophyllum*. Although some of these genera are known in the Upper Devonian as well, they are most abundant in Middle Devonian rocks and often their species constitutes a large portion of the fauna. Cooper & Warthin (1942) cite several Cedar Valley genera which are unknown from late Devonian rocks and list significant elements absent from the Cedar Valley, emphasizing the Middle Devonian aspect of the Cedar Valley as being predominant.

Furthermore, according to Cooper & Warthin (1942), Stainbrook's Upper Devonian Age of the Cedar Valley, based on the position of the Independence shale, also presents a problem. An undoubted Chemung fauna is found in this shale, but Stainbrook (1935) believes it to lie stratigraphically below the Cedar Valley.

Müller (1957) believes the Independence shale is younger than the Cedar Valley. He concluded that the conodonts of the Independence shale near the type locality, and at several other localities in eastern Iowa, are early Upper Devonian in age, and the Cedar Valley is Middle Devonian. The phenomenon of inverted stratigraphic sequence resulted from sedimentation within Cedar Valley solution cavities by a transgressing Independence sea—a view long held by many Iowa stratigraphers and paleontologists. Outcrops of the Independence are few, small, and scattered and, according to Copper & Warthin, the ones they have seen afford evidence such that its postulated position below the Cedar Valley is doubtful.

Stainbrook (1935), although convinced that the Cedar Valley was Upper Devonian in age, correlated it with unquestionable Middle Devonian rocks. He stated that the Cedar Valley is related faunally to the Upper part of the Traverse beds as developed at Partridge Point, Michigan, and is probably of equal age. Cooper & Warthin (1942) point out, however, that the beds of the Thunder Bay formation at Partridge Point underlie the Squaw Bay limestone which is earliest Genesee in age (carrying the goniatite *Koenenites*) and correlated with the basal Upper Devonian Genundewa limestone of New York.

The dating of some of the parts of the Cedar Valley presents problems in addition to the difficulty in dating the entire body. The Solon member is linked with the major portion of the formation by the common presence of the unusual crinoid *Stereocrinus*. Cooper & Cloud (1938) proposed the correlation of the Solon with the Rogers City limestone of Michigan owing to the occurrence of *Rensselandia* in both. Cooper & Warthin (1942) state that Stainbrook has convinced them the Solon cannot be separated from the rest of the Cedar Valley.

Correlations.—In addition to the correlations mentioned in the discussion of the age of the Cedar Valley, the following ones are presented: Raasch (1935) believes the Solon member of the Cedar Valley is equivalent to the Lake Church and possibly to the Theinsville of the Wisconsin Devonian. Owing to the occurrence of *Strophеodonta halli* Cleland and its associated fauna at the base of both the Rapid and Milwaukee members, Raasch likewise believes them to be equivalent. Zone C of the Milwaukee appears to correlate with the upper Rapid. Savage (1921) illustrates that strata corresponding to all zones of the Cedar Valley are present in the vicinity of Rock Island, Illinois. The *waterlooensis* zone of the Cedar Valley (top of the Rapid) can be recognized at Annada, Missouri, and nearly all the zones of this formation are represented across the river in Calhoun County, Illinois.

Cooper & Cloud (1938) find just south of Kritesville, Illinois, beds which correlate with the *profunda* zone of the Solon. They find also that beds in Salt Spring Hollow, Illinois, correlate with the *bellulua*, *pentamerella*, and *waterlooensis* horizons of the Rapid.

Both Stainbrook (1944) and Savage (1925) hold the Cedar Valley to be equivalent to the Cooper and Mineola of Missouri on the basis of the generically parallel faunas. Stainbrook (1944) believes the Callaway to be approximately equivalent to the Rapid member. He also lists several species common to the two formations in addition to the ones listed by Branson (1922). Stainbrook (1944) also lists several species which are present in both the Cedar Valley and Snyder Creek formations, emphasizing the relationship suggested by Savage, but he believes that Lime Creek fossils, for the most part, do not bear a close relationship with those of the Synder Creek. Branson (1944) believes the Snyder Creek is probably equivalent to the Sweetland Creek and the Lime Creek of Iowa, and explains the lack of many common species by the probability that the seas were not directly connected. Snyder Creek faunas are believed to have developed in an isolated arm of the sea that formerly extended southward from Iowa.

The uppermost Devonian of the Forest City well in northwestern Missouri may well

be Cedar Valley. Beds equivalent to these are found in the Bedford and Clarinda wells in Iowa (Stainbrook, 1944). Stainbrook agrees with the suggestion of Hall (1934) that the Ediger limestone of central Kansas is probably equal to the Callaway and Mineola as well as the Cedar Valley. The basis for this belief is the occurrence of long-winged *Spirifer* and a *Cyrtina* in a piece of core of Ediger limestone—strongly suggestive of Cedar Valley forms, as are the fossils from the Ediger listed by Hall.

Lithologically, the Ediger appears to be related to the Cedar Valley, similarity of deposition being suggested by a sandstone at the base of the Ediger (Stainbrook, 1944). Johnston (1934) points out that the spirifers of the Ediger appear to be characteristic of Upper Devonian and later forms.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to Dr. William M. Furnish of the State University of Iowa for help and encouragement leading to the completion of this study. Also, I am indebted to Dr. Charles W. Collinson of the Illinois Geological Survey, and Dr. H. Garland Hershey, Fred H. Dorheim, and Russell B. Campbell of the Iowa Geological Survey, for their invaluable advice and assistance. The writer also wishes to express his thanks to Mr. Henry V. Wormhoudt of New Industries for Ottumwa Incorporated, for relinquishing a portion of a drill core containing Cedar Valley strata.

STRATIGRAPHIC OCCURRENCE OF CHITINOZOA

CHITINOZOAN LOCALITIES

All the material studied in detail in this report came from two localities and provides an over-all coverage of the Cedar Valley formation.

Locality 1.—A 65–70 foot face of Cedar Valley limestone is exposed at the River Products Company quarry, located just north of the Iowa River about a half mile west of old Highway 218, north of center, sec. 33, T. 80 N., R. 6 W., in Johnson County, Iowa, 2 miles north of Iowa City. Samples were collected at one-foot intervals from the lowest point on the face to the top. This included essentially the entire Rapid member and all of the Coralville. The presence of *Atrypa bellula*, which marks the base of the Rapid, has not been definitely established here, but it is believed the floor of the quarry is no more than one or two feet above the top of the Solon (Fred Dorheim, Iowa Geological Survey, personal communication).

Locality 2.—A wedge sawed from an 81-foot portion of a two-inch drill core from the Rex Dimmitt farm in the NW¼, SW¼, NE¼, sec. 33, T. 73 N., R. 13 W., Wapello County, 4 miles northeast of Ottumwa, Iowa, was obtained and sampled at two-foot intervals. The portion of the core includes the entire Solon and the lower few feet of the Rapid members of the Cedar Valley.

The Milan Quarry, from which Collinson & Scott collected the specimens of their 1958 report, is located just south of Rock Island, Illinois, and is 55 air miles from the Coralville locality. The Wapello County location is 100 air miles from the Milan Quarry, and 65 air miles from the Coralville locality.

Another location investigated for chitinozoans by the writer was the type section area of the Solon member. Random samples yielded specimens comparable to those found in the Solon portion of the Ottumwa area core, but this material was not included in this investigation owing to the extremely poor condition of the outcrop. The abandoned quarry appears to be a dumping area, and a major portion of the unit is covered with a considerable amount of debris.

OCCURRENCE OF CHITINOZOANS IN THE CEDAR VALLEY LIMESTONE

Chitinozoans recovered from the locality in Johnson County were, as a rule, well preserved. Limestone from the Rapid member yielded a great many specimens, the microfossils in general being fairly uniformly distributed throughout except for the biostrome in which none was found. The Coralville member was found to be entirely barren of chitinozoans.

Specimens obtained from the core from Wapello County were, for the most part, rather uncommon and not uniformly distributed. In many cases the state of preser-

vation of the microfossils was poor, with crushed specimens causing difficulties in identification. The thick section in this area may represent a deeper area in the basin of deposition, possibly accounting for the scarcity of specimens.

Text-figures 1 and 2 were constructed in order to show the distribution of the chitinozoans within the Cedar Valley, and to illustrate the occurrence of 13 species which are referable to four genera.

All specimens are dark amber to black in color except for the thin collars which are pale amber and translucent.

DISTRIBUTION OF CHITINOZOAN SPECIES WITHIN THE CEDAR VALLEY

The distribution of specimens recovered from the composite sampling of the Cedar Valley seems to indicate some basis for differentiation of its members. *Ancyrochitina spinosa* (Eisenack) appears to be a characteristic species of the Solon but does not occur in the Rapid member. The species *Ancyrochitina cornigera* Collinson & Scott, *A. megastyla* Collinson & Scott, *Earlachitina latipes* Collinson & Scott, *Angochitina capillata* Eisenack, and *Sphaerochitina collinsoni* Dunn, n. sp., were found in the Rapid member but not in the Solon. Most other species listed by Collinson & Scott (1958) were found in both the Rapid and Solon members. The Coralville member was found to be entirely barren of chitinozoans. Text-figures 1 and 2 were compiled to show the occurrence of species found in the Cedar Valley material of this report.

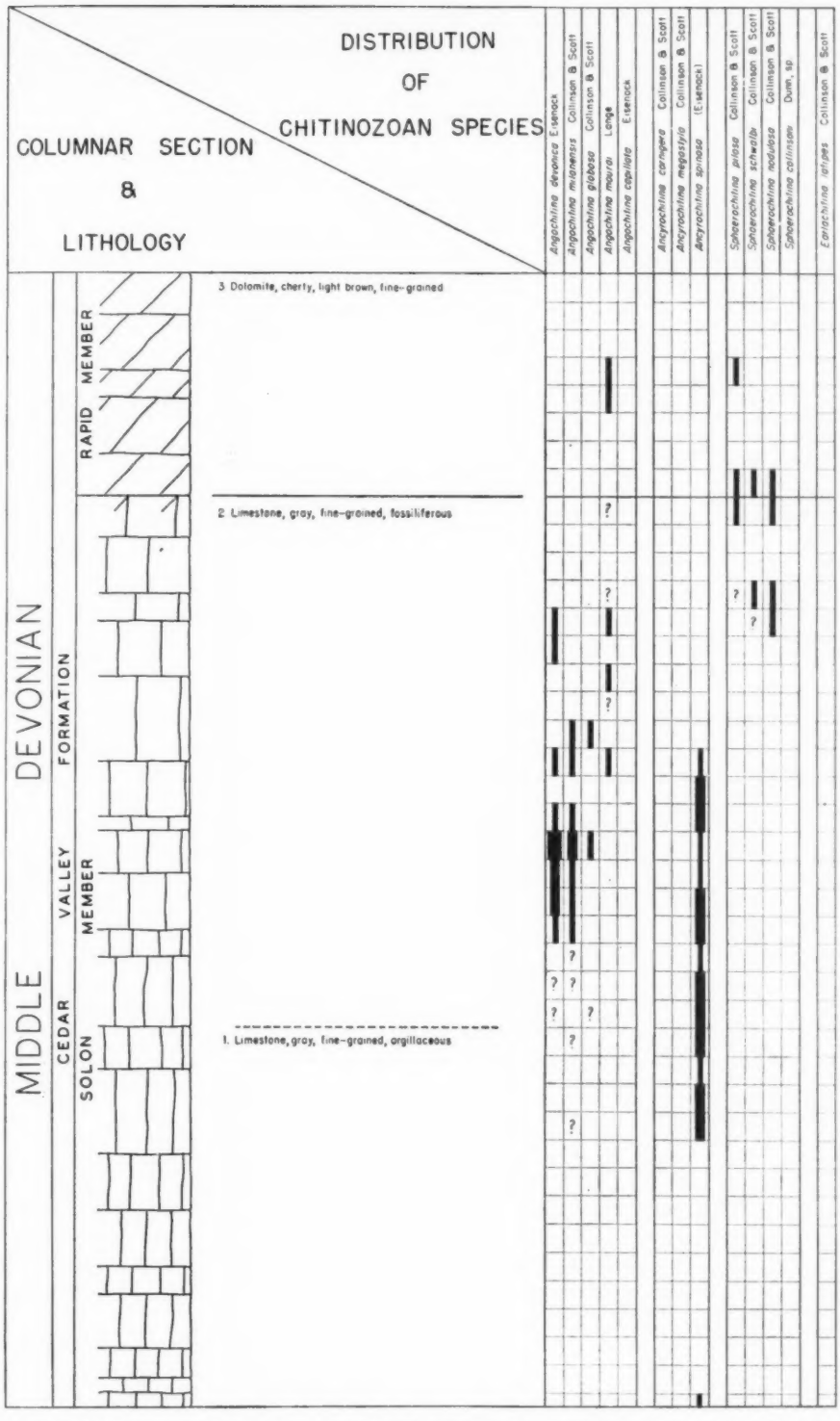
The conclusion is drawn by the writer that Collinson & Scott may be mistaken in referring to the Cedar Valley exposure at the Milan Quarry as being composed entirely of the Solon member. According to my preliminary investigations the following Rapid species are probably diagnostic: *Ancyrochitina cornigera* Collinson & Scott, *A. megastyla* Collinson & Scott, and *Earlachitina latipes* Collinson & Scott. If so, their listing in the Solon by Collinson & Scott was in error; the source of their samples was from the Rapid member. In addition, the species listed by Collinson & Scott (1958) as occurring in the Solon were found to correspond more closely to those recovered by the writer from the Rapid member. For example, *Ancyrochitina spinosa* (Eisenack) was not referred to in the "Solon" of Collinson & Scott, but was found by the writer to be a characteristic species of the Solon. Furthermore, Stainbrook (1935) has reported the Solon to be only 8 to 12 feet thick at the Linwood Quarry in Scott County, Iowa, with 67 feet of Rapid in this same area which is only 7 or 8 miles from Milan, Illinois.

COMPARISON WITH RELATED FAUNAS

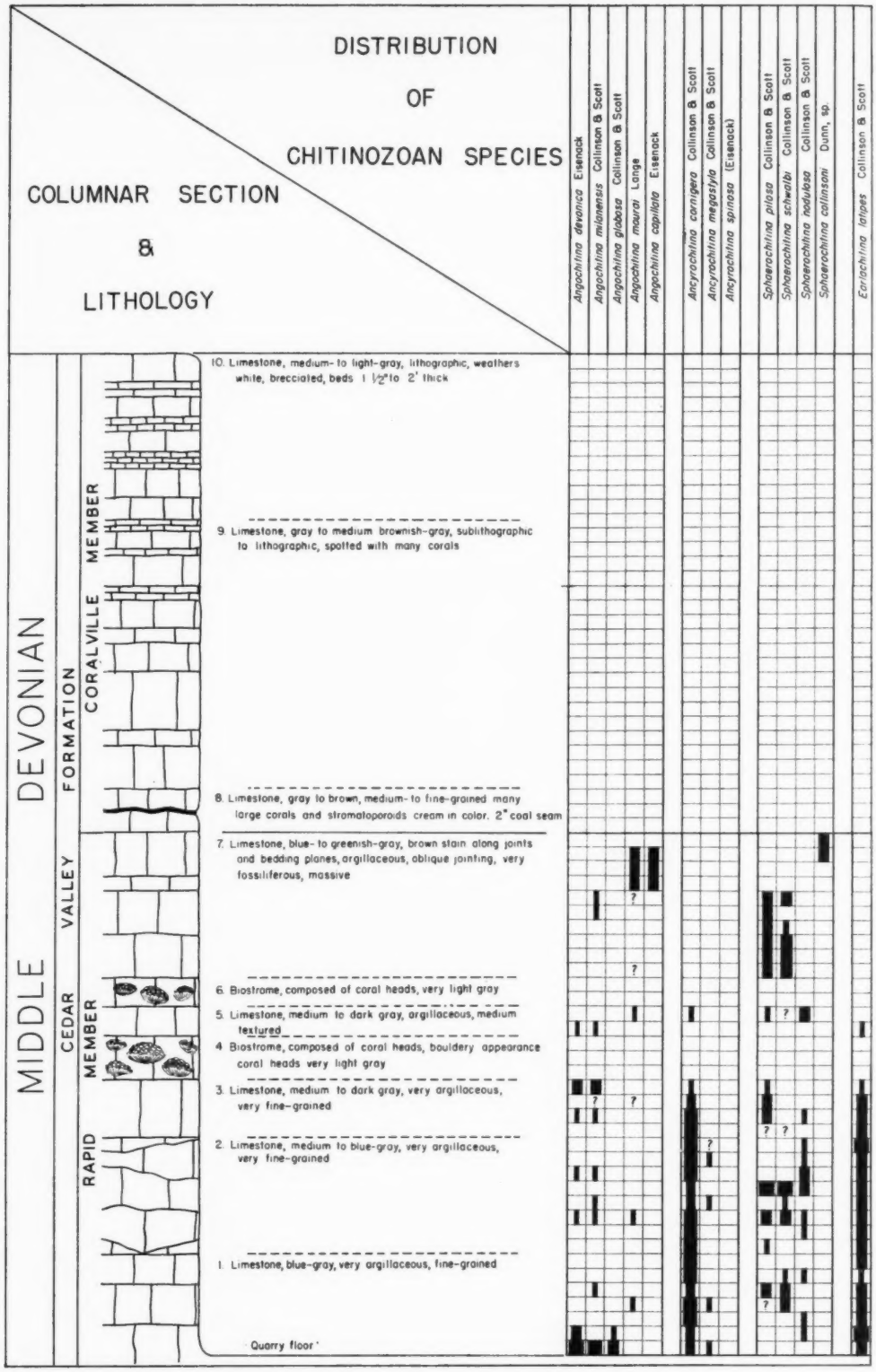
Collinson & Schwalb (1955) list some twenty occurrences of chitinozoans in North America as part of a summary of their distribution. Three distinct faunas of Devonian age are mentioned—one from the Clear Creek formation, recovered from samples representing several wells in the Illinois Basin; a second from the Bailey formation in southern Illinois and western Indiana; and a third from the Grand Tower formation in eastern and western Illinois. In 1958 a fourth Devonian chitinozoan fauna was reported by Collinson & Scott from the Cedar Valley formation in northwestern Illinois. This fauna proved to be quite abundant and diversified, and represents the youngest known occurrence of these microfossils to date. It was found to be quite distinct from other Devonian faunas in general aspect, and to contain important elements theretofore undescribed.

Occurrences of Devonian chitinozoans in other countries included those reported by Lange from the Lower Devonian Ponta Grossa shale (1949), and the Middle Devonian Barreirinha shale (1952), both formations of southern Brazil. They have also been reported as occurring in the lower Middle Devonian Rommersheimer beds of central-western Germany (Eisenack, 1955b) Although not described in the literature, chitinozoans were reported to be common in Devonian rocks of Alberta by L. E. Workman, Canadian Stratigraphic Service, Ltd., Calgary, by personal communication to Collinson & Schwalb (1955).

In addition to the Cedar Valley fauna, only two others in North America are known with any degree of completeness. They are the lower Middle Devonian Clear Creek fauna and the Lower Devonian



TEXT-FIG. *1*—Chitinozoan distribution chart based on samples from Locality 2. The width of the solid line indicates relative abundance, and each vertical division represents two feet. Question marks indicate uncertain identification due to scarcity of well preserved specimens.


DISTRIBUTION
OF
CHITINOZOAN SPECIES
COLUMNAR SECTION
&
LITHOLOGY
Angochitina devonica Eisenack
Angochitina milanensis Collinson & Scott
Angochitina glabosa Collinson & Scott
Angochitina maurai Lange
Angochitina capillata Eisenack
Ancyrochitina carnigera Collinson & Scott
Ancyrochitina megastyla Collinson & Scott
Ancyrochitina spinosa (Eisenack)
Sphaerochitina pilosa Collinson & Scott
Sphaerochitina schwalbi Collinson & Scott
Sphaerochitina nodulosa Collinson & Scott
Sphaerochitina collinsoni Dunn, sp.
Eoviachitina latipes Collinson & Scott
MIDDLE DEVONIAN
CEDAR VALLEY FORMATION
RAPID MEMBER
CORALVILLE MEMBER
10. Limestone, medium- to light-gray, lithographic, weathers white, brecciated, beds 1 ½" to 2' thick
9. Limestone, gray to medium brownish-gray, sublithographic to lithographic, spotted with many corals
8. Limestone, gray to brown, medium- to fine-grained many large corals and stromatoporoids cream in color. 2" coal seam
7. Limestone, blue- to greenish-gray, brown stain along joints and bedding planes, argillaceous, oblique jointing, very fossiliferous, massive
6. Biostrome, composed of coral heads, very light gray
5. Limestone, medium to dark gray, argillaceous, medium textured
4. Biostrome, composed of coral heads, bouldery appearance coral heads very light gray
3. Limestone, medium to dark gray, very argillaceous, very fine-grained
2. Limestone, medium to blue-gray, very argillaceous, very fine-grained
1. Limestone, blue-gray, very argillaceous, fine-grained
Quarry floor

TEXT-FIG. 2—Chitinozoan distribution chart based on samples from Locality 1. The width of the solid line indicates relative abundance, and each vertical division represents one foot. Question marks indicate uncertain identification due to scarcity of well preserved specimens.

Bailey fauna, both of Illinois and Indiana. They are treated in the 1955 report of Collinson & Schwalb.

The Clear Creek fauna is quite well known and according to Collinson & Scott (1958) has been recorded from several localities and wells. They list five species which are referable to two genera. They are: *Lagenochitina brevicervicata* Collinson & Schwalb, *Lagenochitina elongata* Collinson & Schwalb, *Lagenochitina sphaerica* Collinson & Schwalb, *Angochitina flasca* Collinson & Schwalb, and *Angochitina pusilla* Collinson & Schwalb. They report the greatly abundant and thick-walled *Lagenochitina* as the characteristic member of the undiversified fauna. The species belonging to *Angochitina* differ mainly in that they possess spines, but otherwise resemble *Lagenochitina*. By comparison of these species with those found in the Cedar Valley, it is easily ascertained that they bear no similar individuals.

Although knowledge of the Bailey fauna is incomplete, its elements differ considerably from those of both the Cedar Valley and Clear Creek formations. Occurring in the Bailey are: *Lagenochitina sacculus* Collinson & Schwalb, *Lagenochitina sphaerica* Collinson & Schwalb, *Angochitina bifurcata* Collinson & Schwalb, *Desmochitina poculum* Collinson & Schwalb, and *Desmochitina* sp. (Collinson & Scott, 1958).

Lagenochitina sphaerica, one of the most abundant species of the Clear Creek, is an important element of the Bailey fauna. In addition to this, *Lagenochitina sacculus* is very much like Clear Creek forms. There are no other species of the Bailey which correspond to those of the Clear Creek, but *Angochitina bifurcata* resembles other *Angochitina* elements of the Cedar Valley. The genus *Desmochitina* is reported from only one other Devonian fauna—that of the Barreirinha shale of Brazil. However, several species of *Desmochitina* are known to occur in Ordovician and Silurian faunas of Europe (Collinson & Scott, 1958).

Collinson & Scott (1958) report that the Middle Devonian Grand Tower formation of Illinois contains only one species closely related to Cedar Valley representatives of *Angochitina*—that being *Angochitina bifurcata* Collinson & Schwalb.

In addition to those forms reported by Collinson & Scott (1958) from the Milan Quarry, the following elements have been found by the writer to occur in Cedar Valley rocks: *Ancyrochitina spinosa* (Eisenack), *Sphaerochitina collinsoni* Dunn, n. sp., *Angochitina capillata* Eisenack, and *Ancyrochitina* n. spp. The occurrence of *Ancyrochitina spinosa* (Eisenack), and *Angochitina capillata* Eisenack are of special interest owing to the fact that no prior Devonian occurrences of these species have been recorded. *Ancyrochitina spinosa* (Eisenack) was previously reported from the Silurian Crinoidenkalk of the East Prussia Baltic region (Eisenack, 1932), and *Angochitina capillata* Eisenack has been found in the Ordovician Ostseekalk of the Baltic area (Eisenack, 1938).

TECHNIQUES

Sampling.—Samples from the River Products Company Quarry at Coralville, Iowa, were taken at one-foot intervals, or as close to this as possible, such that no single sample included different stratigraphic units. Approximately 200 grams of rock were collected from each interval, or enough to fill a small sample bag.

A wedge sawed from a quarter portion of a two-inch core from the Ottumwa, Iowa, area was sampled at two-foot intervals. The bulk samples from both localities were further broken up with the aid of a mechanical rock crusher before laboratory processing.

Laboratory.—The laboratory procedure followed by the writer varies slightly from that presented by Collinson & Scott (1958). Approximately 30 grams of the crushed rock from each sample interval were treated with 10 per cent hydrochloric acid which served to liberate the chitinozoans from the limestone. These microfossils are not damaged by treatment with the more well-known acids, even if concentrated, owing to the chitin-like nature of the test.

An argillaceous limestone will yield a considerable amount of insoluble clay-sized material which may cause a great deal of difficulty in being able to see the chitinozoans in the residue. The problem can be minimized in the following manner: decant the liquid from the hydrochloric acid treatment and fill the beaker with fresh water; repeat this two or three times. After final

decantation, pour the insoluble material into a plastic container and add at least an equal amount, or slightly more, of 50 per cent hydrofluoric acid. After some time, again add fresh water and after allowing the insolubles to settle, decant the liquid. The residues should then be ready for viewing under the binocular microscope. The writer found a shallow white plastic tray approximately $3 \times 5 \times \frac{3}{8}$ inches ideal for this purpose. Pour a small amount of the insoluble material into the tray and add enough water to make a thin solution about a quarter inch deep.

The microfossils can be extracted from the solution with the aid of a finely-drawn glass pipette. By attaching a length of rubber tubing, sealed at one end, to the pipette, the chitinozoans can be sucked up into it and ejected into a petri dish of fresh water by hand pressure on the tube. The specimens can be separated from the other insoluble material drawn into the pipette by repeatedly transferring them to petri dishes of fresh water—two or three transferals will usually suffice.

Individual specimens can be mounted on micro-slides for viewing and will adhere to the slides after the water has evaporated, and until they are permanently affixed after study. The writer found conodont slides with the wells painted white to be excellent containers for the aggregate specimens from each sample interval.

SYSTEMATIC PALEONTOLOGY

Genus ANGOCHITINA Eisenack, 1931

Type species: *Angochitina echinata* Eisenack, 1931

The genus consists of flask-shaped forms with spines. The type species was reported from the Silurian Beyrichienkalk of the Baltic region. Other species have been reported in rocks from Ordovician to Devonian in age.

ANGOCHITINA DEVONICA Eisenack
Pl. 125, figs. 1,2,4-8

Angochitina devonica EISENACK, 1956, Senkenbergiana lethaea, Bd. 36, p. 315, pl. 1, figs. 10–12; COLLINSON & SCOTT, 1958, Illinois Geol. Survey Circ. 247, p. 29, pl. 1, figs. 6,9,10,14, 18,20,21,24; p. 33, pl. 3, figs. 22,26.

This species is flask-shaped and has a cylindrical neck which tapers gently into the body chamber. The ratio of the neck to the over-all length of specimen ranges from .40 to .45 .It possesses few spines which are often quite long, and simple to multibranching in form. The bases of the latter type are often quite wide and usually translucent. The oral end may be evenly to irregularly truncated and is encircled by a short collar which is often quite thin and translucent. The over-all length ranges from .170 to .210 mm.

Remarks.—*Angochitina devonica* Eisenack is closely related to *Angochitina milanensis* Collinson & Scott, and transitional forms may occur. Eisenack (1955b), in the original description, rather loosely defined the neck length as from about one-half to two-fifths of the total length. Collinson & Scott (1958), in describing the new species *Angochitina milanensis*, state that a ratio of .40 of neck length/over-all length is the criterion for distinguishing these two species; those of greater ratio being referred to *A. devonica* and those of lesser ratio being referred to *A. milanensis*.

Most specimens of *Angochitina devonica* were found to be partly or entirely compressed laterally with consequent splitting of the test.

Occurrence.—Common in the upper half of the Solon member, Cedar Valley forma-

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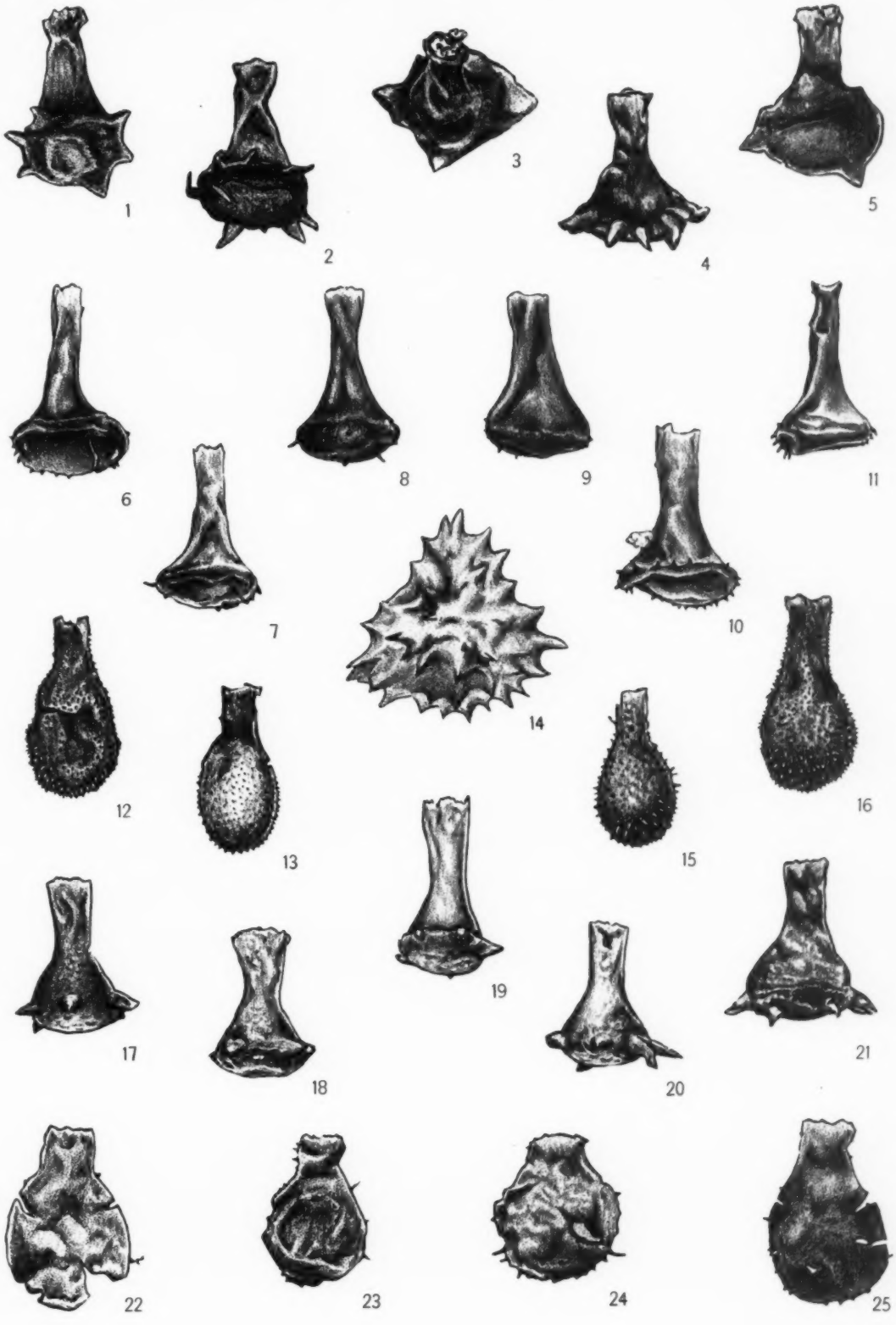
EXPLANATION OF PLATE 126

All specimens from the Cedar Valley limestone near Ottumwa, or Coralville, Iowa, ×200.

FIG. *1–5—Earlachitina latipes* Collinson & Scott.
6–11—Sphaerochitina collinsoni Dunn, n. sp.
12,13,15,16—Angochitina capillata Eisenack.
14—Spore.
17–21—Ancyrochitina cornigera Collinson & Scott.
22–25—Angochitina Globosa Collinson & Scott.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tion, near Ottumwa, Iowa. Uncommon in beds 1, 2, 3, and 5, Rapid member, near Coralville, Iowa. Also reported from comparable Cedar Valley strata at Milan, Illinois, and from the lower Middle Devonian Rommersheimer beds of the Gerolstein basin in the province of Rheinland Pfalz, western Germany.

Repository.—State University of Iowa, 10267–10272, 10277, figured specimens; 10273–10275, unfigured specimens.

ANGOCHITINA cf. A. DEVONICA Eisenack
Pl. 125, fig. 3

Angochitina cf. *A devonica* COLLINSON & SCOTT, 1958, Illinois Geol. Survey Circ. 247, p. 29, pl. 1, figs. 15,17.

A single specimen recovered from Cedar Valley material was found to closely resemble *Angochitina devonica* Eisenack, but has a narrow, indistinct neck. The maximum diameter of the test, near the aboral end, is slightly more than twice the width of the neck, Very few simple spines occur on the test. No collar can be seen on the specimen.

Occurrence.—Rare in bed 3, Rapid member, Cedar Valley formation, near Coralville, Iowa. Also reported in comparable Cedar Valley strata near Milan, Illinois.

Repository.—State University of Iowa, 10276, figured specimen.

ANGOCHITINA MILANENSIS Collinson & Scott
Pl. 125, figs. 17,18,20,21

Angochitina milanensis COLLINSON & SCOTT, 1958, Illinois Geol. Survey Circ. 247, p. 29, pl. 1, figs. 1–5,7,8,19,26.

This species is flask-shaped with a cylindrical neck which tapers gently into the body chamber. It is very much like *A. devonica* Eisenack except that the ratio of the neck to the over-all length of specimen is less, ranging from .26 to .38. The few spines occurring on the test may consist of any combination of simple, bifurcate, or multibranching types, some often being quite long. The bases of the latter type are in many cases quite wide and translucent. The oral end may be evenly to irregularly truncated, and is terminated by a short, thin, and usually translucent collar. The over-all length ranges from .130 to .175 mm.

Most specimens observed appear to have been partly or entirely compressed laterally, with consequent splitting, and often have portions of the test broken away.

Occurrence.—Common in the middle third of the Solon member, Cedar Valley formation, near Ottumwa, Iowa. Uncommon in beds 1, 2, 3, 5, and 7, Rapid member, near Coralville, Iowa. Also reported from comparable Cedar Valley strata at Milan, Illinois.

Repository.—State University of Iowa, 10278–10281, figured specimens; 10282, 10283, unfigured specimens.

ANGOCHITINA GLOBOSA Collinson & Scott
Pl. 126, figs. 22-25

Angochitina globosa COLLINSON & SCOTT, 1958, Illinois Geol. Survey Circ. 247, p. 29, pl. 1, figs. 11,13,22,23,25.

This species has a globular body chamber with a short cylindrical neck. It resembles *Angochitina milanensis* Collinson & Scott except that it appears to bear only simple and bifurcate spines. Multibranching types are absent. The ratio of neck length to over-all length of *A. globosa* ranges from .21 to .26. The oral end may be evenly to irregularly truncated and is encircled by a short collar which is usually quite thin and translucent. The over-all length ranges from .12 to .15 mm.

EXPLANATION OF PLATE 127

All specimens from the Cedar Valley limestone near Ottumwa, or Coralville, Iowa, ×200.

FIG. *1–4*—*Ancyrochitina megastyla* Collinson & Scott.
5–8—*Sphaerochitina schwalbi* Collinson & Scott.
9–13—*Sphaerochitina pilosa* Collinson & Scott.
14,18—*Ancyrochitina* n. spp.
15,17—Cysts?
16—Spore.
19–23—*Ancyrochitina spinosa* (Eisenack).

Remarks.—The body chamber of *Angochitina globosa* has, in most cases, a diameter greater than that of *A. milanensis*, owing to its globular shape. The neck is generally shorter than that of *A. milanensis*. Collinson & Scott (1958) report the neck length/over-all length ratio varies from .29 to .42.

Most specimens of *Angochitina globosa* are partly or entirely compressed laterally with consequent splitting of the test.

Occurrence.—Rare in the Solon member, Cedar Valley formation, near Ottumwa, Iowa. Uncommon in bed 1, Rapid member, near Coralville, Iowa. Reported common in comparable Cedar Valley strata at Milan, Illinois.

Repository.—State University of Iowa, 10259–10262, figured specimens.

Angochitina Mourai Lange
Pl. 125, figs. 9-11

Angochitina mourai Lange, 1952, Dusenia, v. 3, p. 377–379, pl. 18, figs. 7–9, pl. 19, figs. 10–12; Eisenack, 1955b, Senckenbergiana lethaea, Bd. 36, p. 315, pl. 1, fig. 16; Collinson & Scott, 1958, Illinois Geol. Survey Circ. 247, p. 29, pl. 1, fig. 11.

This species is typically flask-shaped but the body chamber tends to be somewhat globular in form. It has a cylindrical neck, irregularly to evenly truncated, which is terminated at the oral end by a thin translucent collar. The ratio of neck length to over-all length of specimen ranges from .27 to .37. Ornamentation of the test consists of many short, simple, rarely bifurcate spines. The over-all length ranges from .123 to .185 mm.

Remarks.—*Angochitina mourai* is closely related to *A. globosa* Collinson & Scott, but has a slightly longer neck and considerably shorter, simpler, and more numerous spines.

As in the case of most specimens of *Angochitina*, the tests of this species have been crushed laterally and consequently split.

Occurrence.—Uncommon in the upper half of the Solon and lower part of the Rapid members, Cedar Valley formation, near Ottumwa, Iowa; uncommon in the Rapid member, near Coralville, Iowa.

Repository.—State University of Iowa, 10263–10265, figured specimens; 10266, unfigured specimen.

Angochitina capillata Eisenack
Pl. 126, figs. 12,13,15,16

Angochitina capillata Eisenack, 1937, Paleontologische Zeitschrift, Bd. 19, p. 359, pl. 15, figs. 12,13.

This species is typically flask-shaped and has a cylindrical neck which tapers gently into the body chamber. The ratio of neck length to over-all length ranges from .30 to .38. It possesses numerous, closely set, very short, erect spines over the entire body chamber and in most cases on the neck as well. The oral end is evenly to irregularly truncated and is encircled by a short, thin, usually translucent collar. The over-all length ranges from .130 to .160 mm.

Remarks.—*Angochitina capillata* may possibly be confused with *A. mourai* Lange, but can be differentiated by the complete lack of bifurcate spines in *A. capillata* and the more globular-shaped body chamber of *A. mourai*.

Occurrence.—Common in the uppermost 4 feet of bed 7, Rapid member, Cedar Valley formation, near Coralville, Iowa. Also reported from the Ordovician Ostseekalk of the Baltic region.

Repository.—State University of Iowa, 10246–10249, figured specimens; 10250, unfigured specimen.

Genus Ancyrochitina Eisenack, 1955

Type species: *Conochitina ancyrea* Eisenack, 1931

The genus consists of forms with conical, or rarely, spherical body chambers; subcylindrical necks, one-half to two-thirds of the total length of specimen, and four to ten simple, bifurcate or multibranching spines near the aboral end. The base of the body chamber is generally slightly convex, but may be weakly concave. The type species was reported from the Silurian Chonesteskalk of the Baltic region. Other species have been reported in rocks from Ordovician to Devonian in age.

Collinson & Schwalb (1955) proposed the name *Ampullachitina* for this group of species which Eisenack (1955a), earlier in the year, had named *Ancyrochitina*. *Ancyrochitina*, therefore, takes precedence and *Ampullachitina* should be considered a junior synonym (Collinson & Scott, 1958).

ANCYROCHITINA CORNIGERA Collinson & Scott
Pl. 126, figs. 17-21

Ancyrochitina cornigera COLLINSON & SCOTT, 1958, Illinois Geol. Survey Circ. 247, p. 31, pl. 2, figs. 4,5,15–19.

Typically, this species has a conical body chamber, with a generally long cylindrical neck which may be slightly expanded orally. The base of the body chamber may be flat or slightly convex. The neck joins the body chamber in a tapering manner at approximately mid-length of the specimen, and is terminated orally by a short, indistinct, thin, and translucent collar. The ratio of neck length to over-all length ranges from .38 to .57. Several nodular to spike-like spines (usually six) are found around the periphery of the widest portion of the body chamber, near the aboral end. They may vary in length from about one-eighth to one-third of the total body width. The over-all length ranges from .110 to .135 mm.

Remarks.—Collinson & Scott (1958) recognize the similarities of this species with *Ancyrochitina diabolo* (Eisenack), but emphasize that *A. diabolo* has a characteristically longer neck, and that *A. cornigera* has a greater apical angle (imaginary vertex angle of the conical body chamber). Despite these differences, specimens of *A. cornigera* were found (Pl. 126, figs. 17,18,20) with apical angles several degrees greater than the range (35°–50°) specified by Collinson & Scott, but falling within the limits of neck length/over-all length ratio of .36 to .50. Conversely, specimens were found with greater neck length/over-all length ratios than *A. diabolo*, but within the limits of apical angle for *A. cornigera*.

Occurrence.—Abundant in beds 1, 2, 3, and 5, Rapid member, Cedar Valley formation, near Coralville, Iowa. Also reported from comparable Cedar Valley strata near Milan, Illinois.

Repository.—State University of Iowa, 10251–10255, figured specimens; 10256–10258, unfigured specimens.

ANCYROCHITINA MEGASTYLA Collinson & Scott
Pl. 127, figs. 1-4

Ancyrochitina megastyla COLLINSON & SCOTT, 1958, Illinois Geol. Survey Circ. 247, p. 31, pl. 2, figs. 1–3,7.

Typically, this species has a subconical body chamber with a long cyclindrical neck which tapers into the body chamber at about half to a third of the distance from the base. The base of the body chamber may be flat or slightly convex. The most characteristic feature of this species is the large, broad, hollow, attenuate spines which taper from the body chamber at its maximum diameter near the aboral end. The ratio of neck length to over-all length ranges from at least .43 to .67. The over-all length ranges from about .116 to .160 mm.

Remarks.—*Ancyrochitina megastyla* is closely related to *A. cornigera* but can be distinguished by the broad attenuate spines and greater ratio of neck length to over-all length of *A. megastyla*.

Occurrence.—Uncommon in beds 1 and 2, Rapid member, Cedar Valley formation near Coralville, Iowa. Also reported from comparable Cedar Valley strata near Milan, Illinois.

Repository.—State University of Iowa, 10212–10215, figured specimens; 10216, unfigured specimen.

ANCYROCHITINA SPINOSA (Eisenack)
Pl. 127, figs. 19–23

Conochitina spinosa EISENACK, 1937, Paleontologische Zeitschrift, Bd. 19, p. 359, pl. 15, figs. 12,13.

This species is characterized by a conical body chamber and a cylindrical neck two-fifths to one-half the total length of the specimen. The test has a slightly- to well-rounded base and is adorned from oral to aboral end with many simple, bifurcate, and occasionally multibranching spines. The spine bases appear to be circular in cross-section. The oral end of the neck is irregularly fringed and is encircled by a thin translucent collar. The ratio of neck length to over-all length ranges from .40 to .47. The over-all length ranges from .130 to .155 mm.

Remarks.—*Ancyrochitina spinosa* has not previously been reported from Devonian rocks.

Occurrence.—Abundant in the middle third of the Solon member, Cedar Valley formation, near Ottumwa, Iowa. Also re-

ported from the Silurian Crinoidenkalk of the East Prussia Baltic region.

Repository.—State University of Iowa. 10200–10204, figured specimens; 10205, unfigured specimen.

ANCYROCHITINA n. spp.
Pl. 127, figs. 14,18

Single representatives of apparently two new species of *Ancyrochitina* were recovered from Cedar Valley strata near Coralville, Iowa. Both specimens have body chambers almost identical with *A. cornigera*, but the characteristic feature of these new species is their extremely long necks which bear one to four short, spike-like spines. The specimen of Figure 14, Plate 127, has a neck length/over-all length ratio of .68 and an over-all length of .190 mm. The specimen of Figure 18, Plate 127, has a neck length/over-all length ratio of .73 and an over-all length of .240 mm. The shorter of these two specimens appears to be transitional between *A. cornigera* and the longer one.

Occurrence.—Rare in beds 2 and 7, Rapid member, near Coralville, Iowa.

Repository.—State University of Iowa, 10206, 10207, figured specimens.

Genus SPHAEROCHITINA Eisenack, 1955
Type species: *Lagenochitina sphaerocephala* Eisenack, 1931

The genus is characterized by forms with cone-, sphere-, or broadly mushroom-shaped body chambers and subcylindrical necks. Ornamentation of the test, if present, consists of tiny nodes or small, thick, erect spinules. The type species was reported from the Silurian Beyrichienkalk of the Baltic region.

SPHAEROCHITINA COLLINSONI Dunn, n. sp.
Pl. 126, figs. 6–11

This species has a long cylindrical neck which flares out near the aboral end into a mushroom-shaped body chamber. The base of the body chamber is well rounded. The oral end of the neck is encircled by a thin translucent collar. Ornamentation on the smooth exterior of the test consists of a single row of short, small, erect spines which encircle the body chamber at its maximum diameter near the aboral end. The ratio of neck length to over-all length ranges from .63 to .71. The over-all length varies from .130 to .150 mm.

Remarks.—This species is somewhat similar to *Ancyrochitina laguncula* (Collinson & Schwalb), but can be distinguished by its mushroom-shaped body chamber, shorter spines, and greater ratio of neck length to over-all length.

The bases of the body chambers in many of the specimens are strongly concave but this can be attributed to collapse during preservation.

Derivation of name.—In honor of Dr. Charles W. Collinson of the Illinois State Geological Survey, for his contribution to the study of North American chitinozoans.

Occurrence.—Common in the uppermost 2 feet of bed 7, Rapid member, Cedar Valley formation, near Coralville, Iowa.

Repository.—State University of Iowa, 10219 (holotype), 10217, 10218, 10220–10222 (paratypes), figured specimens; 10223, 10224 (paratypes), unfigured specimens.

SPHAEROCHITINA PILOSA Collinson & Scott
Pl. 127, figs. 9–13

Sphaerochitina pilosa COLLINSON & SCOTT, 1958, Illinois Geol. Survey Circ. 247, p. 33, pl. 3, figs. 1–5.

The body chamber of this species is generally conical in shape with the maximum diameter near the aboral end. It has a flat, slightly convex base. A cylindrical neck tapers into the body chamber at approximately mid-length of the test, and is encircled by a short collar at the aboral end. The ratio of neck length to over-all length ranges from .48 to .54. Ornamentation of the test consists of many close-set, very fine spines which occur on the neck as well as the body chamber. The over-all length ranges from .120 to .150 mm.

Remarks.—Collinson & Scott (1958) have reported individuals of this species which range up to .190 mm. in length.

Occurrence.—Uncommon in lower portion of Rapid member, Cedar Valley formation, near Ottumwa, Iowa; abundant in beds 1, 2, 3, and 7, Rapid member, near Coralville, Iowa. Also reported from comparable Cedar Valley strata near Milan, Illinois.

Repository.—State University of Iowa, 10240–10244, figured specimens; 10245, unfigured specimen.

SPHAEROCHITINA SCHWALBI
Collinson & Scott
Pl. 127, figs. 5–8

Sphaerochitina schwalbi COLLINSON & SCOTT, 1958, Illinois Geol. Survey Circ. 247, p. 33, pl. 3, figs. 6–10.

This species has a conical body chamber with a maximum diameter near the aboral end. The base of the body chamber is flat to slightly convex. A short cylindrical neck tapers into the body chamber. The oral end of the neck is encircled by a thin translucent collar. The ratio of neck length to over-all length ranges from .35 to .42. Ornamentation of the test consists of many close-set, very fine spines which occur on the body chamber and neck as well. The over-all length ranges from .095 to .115 mm.

Remarks.—*Sphaerochitina schwalbi* is very similar to *S. pilosa*, the only apparent difference being the shorter length and therefore smaller ratio of neck length to over-all length of *S. schwalbi*.

Collinson & Scott (1958) report individuals ranging up to .114 mm. in over-all length.

Occurrence.—Uncommon in lower portion of Rapid member, Cedar valley formation, near Ottumwa, Iowa; common in beds 1, 2, and 7, Rapid member, near Coralville, Iowa.

Repository.—State University of Iowa, 10225–10228, figured specimens; 10229–10232, unfigured specimens.

SPHAEROCHITINA NODULOSA
Collinson & Scott
Pl. 125, figs. 12–16, 19

Sphaerochitina nodulosa COLLINSON & SCOTT, 1958, Illinois Geol. Survey Circ. 247, p. 33, pl. 3, figs. 15–19,23,25.

The body chamber of this species is cone- to slightly mushroom-shaped. A subcylindrical neck, terminated at the oral end by a thin translucent collar, tapers into the body chamber at approximately mid-length of the specimen. The base of the body chamber is slightly convex. Ornamentation of the test consists of several randomly-placed, short, thick spines or small tubercles which are almost entirely confined to the lower portion of the body chamber. The apical angle ranges from 37° to 74°.

Remarks.—Most specimens appear to have had portions of the neck broken off so that an accurate range for the total neck lengths is unavailable. Collinson & Scott (1958), however, report the average neck length as about .170 mm. Furthermore, they recorded the apical angles as ranging from 42° to 55°, which is less than most of those measured by the writer. Despite the greater apical angles, the characteristic spine ornamentation and conical body chamber warranted the classification of this material with *Sphaerochitina nodulosa*.

Occurrence.—Uncommon in upper 10 feet of the Solon member, Cedar Valley formation, near Ottumwa, Iowa. Common in beds 1, 2, 3, and 5, Rapid member, near Coralville, Iowa. Also reported from comparable Cedar Valley strata near Milan, Illinois.

Repository.—State University of Iowa, 10284, 10286–10290, figured specimens; 10285, unfigured specimens.

Genus EARLACHITINA Collinson & Scott, 1958

Type species: *Earlachitina latipes* Collinson & Scott, 1958

The genus is characterized by forms with depressed, subconical to subdiscoidal body chambers and subcylindrical necks, with or without collars, terminated at the oral end by a simple aperture. The body chamber at its maximum diameter near the aboral end is ornamented with a variable number of spines formed by extensions of the body chamber. A few spines may occur on the neck and collar but otherwise the walls of the test are smooth. The base of the body chamber may be slightly concave or slightly convex. The type species was reported from the Cedar Valley formation near Milan, Illinois.

EARLACHITINA LATIPES Collinson & Scott
Pl. 126, figs. 1–5

Earlachitina latipes COLLINSON & SCOTT, 1958, Illinois Geol. Survey Circ. 247, p. 31, pl. 2, figs. 8,9,12–14,20–24; p. 33, pl. 3, figs. 13,24.

This species consists of forms with subcylindrical necks which flare out rapidly near the aboral end into a subdiscoidal body chamber. The oral end of the neck is encircled by a short, thin, translucent collar. The brim of the body chamber bears from three to seven or eight broad to moderately-

broad spines of variable length. The base of the body chamber is slightly concave. The surface of the test is smooth. Over-all length varies from .100 to .120 mm.

Remarks.—Collinson & Scott (1958) report over-all length varies from .109 to .167 mm. Also, according to them, one or two short, stout spines may occur on the collars or necks of some individuals.

Occurrence.—Abundant in beds 1, 2, and 3; rare in bed 5, Rapid member, Cedar Valley formation, near Coralville, Iowa. Also reported from comparable Cedar Valley strata near Milan, Illinois.

Repository.—State University of Iowa, 10233–10237, figured specimens; 10238, 10239, unfigured specimens.

SPORES

Pl. 126, fig. 14; Pl. 127, fig. 16

Spores of various shapes and ranging up to about .20 mm. in diameter were found to be abundant in virtually all samples of Cedar Valley material.

A common type is illustrated in figure 14, Plate 126. From the polar view it is semi-angular in shape, but it is biconvex from equatorial view. The surface is echinate, bearing many spines over the entire surface. It is brownish-yellow in color.

Another common type is shown in Figure 16, Plate 127. It is shaped like an oblate spheroid. It is acolpate, smooth-surfaced, and dark amber in color.

Occurrence.—Abundant in Solon and Rapid members of the Cedar Valley formation near Ottumwa, Iowa. Abundant in Rapid and Coralville members, near Coralville, Iowa.

Repository.—State University of Iowa, 10211, 10208, figured specimens.

CYSTS?

Pl. 127, figs. 15,17

Cysts? COLLINSON & SCOTT, 1958, Illinois Geol. Survey Circ. 247, p. 33, pl. 3, fig. 21.

Several black, smooth-surfaced, spherical to ovoid bodies, apparently composed of material similar to that of chitinozoan tests were recovered from Cedar Valley material. The nature of the bodies is not known but, as suggested by Collinson & Scott (1958), they may possibly represent an encysted stage of Chitinozoa.

Occurrence.—Common in Solon and Rapid members near Ottumwa, Iowa. Common in Rapid member, near Coralville, Iowa. Also reported from comparable Cedar Valley strata near Milan, Illinois.

Repository.—State University of Iowa, 10209, 10210, figured specimens.

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LOWER JURASSIC BRACHIOPODS FROM TURKEY

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ABSTRACT—A large and varied Lower Jurassic (Liassic) brachiopod fauna is described from Yakaçik near Ankara. It is compared with other Turkish faunas and with those of Europe. It is shown to have many affinities with the faunas of northwest Europe and to include some Alpine elements. The geographical and stratigraphical range of each species is discussed.

INTRODUCTION

THE author recently had the good fortune to visit various geological establishments in Turkey. Through the kindness of many Turkish geologists, he was able to examine all the available collections of Jurassic brachiopods and to visit various localities where these could be collected. The most valuable collection came from the Lower Jurassic near the village of Yakaçik, about 16 km. north-northwest of Ankara. This fauna is described here. The chief interest to the author lies in the strong northwest European affinities of the Turkish faunas and the light they may eventually throw on the relationship between geographical distribution and the evolution of the various genera present.

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The visit to Turkey was made possible by a travelling grant from the Hilary Bauerman bequest. Special thanks are also due to Miss Elaine Bryant who took the photographs and prepared the serial sections. All the figured specimens have been presented to the British Museum (Natural History).

THE YAKAÇIK FAUNA

Yakaçik is a small village in the arid and roadless country northwest of the Turkish capital. The geology of the neighborhood is complex, and the only useful detailed account of it is contained in an unpublished report by Blumenthal at the M.T.A. in Ankara. Recently, there was a brief note about Yakaçik in a general account of the structure of the Ankara region by Bailey and McCallien (1954).

The Lias is seen as a dark red limestone just north of the village, on either side of a small valley. It appears to rest unconformably on hard, Palaeozoic greywackes exposed on the valley bottom. Fossils were collected at two localities—on either side of the valley—but nearly all came from the thin mantle of loose material which, for the most part, conceals the solid rocks. As judged from the nature of the country and of the exposures, this was unavoidable; there is no doubt that the specimens came from only a few feet of sediment. A large number of brachiopods were collected. There were also a large ammonite fauna, abundant crinoids and pelecypods, and occasional gastropods and belemnites.

A fauna from here was described by Vadasz (1913), but this account was based only on one or two specimens each of a few species; only two brachiopods were figured.

The ammonites collected by the author were examined by Dr. M. K. Howarth of the British Museum (Natural History). He identified *Coroniceras* cf. *C. rotiforme* (J. de C. Sowerby) and *Phylloceras alontinum* (Gemmellaro), both indicative of the *C. bucklandi* zone, from the east side of the valley,

and *Eoderoceras* cf. *E. armatum* (J. Sowerby), indicative of the *raricostatum* zone from the west side. Several of the brachiopod species, however, were found on both sides of the valley, and it seems probable that they came from the same highly condensed succession of the Lower and Middle Lias.

SYSTEMATIC PALEONTOLOGY

Family RHYNCHONELLIDAE Gray, 1848
Genus HOMOEORHYNCHIA Buckman, 1918
HOMOEORHYNCHIA ACUTA (J. Sowerby)
Pl. 128, figs. 1 a–c

Terebratula acuta J. SOWERBY, 1816, Mineral Conchology, v. 2, p. 115, pl. 150, figs. 1 & 2; QUENSTEDT, 1852, Handb. Petrefaktenkunde, p. 452, pl. 36, fig. 15.

Rhynchonella acuta DAVIDSON, 1852, Palaeontogr. Soc. Monogr., p. 76–77, pl. 14, figs. 8 & 9.

Homoeorhynchia acuta BUCKMAN, 1918, Palaeont. Indica, N.S., v. 3, p. 36–38, pl. 18, fig. 13; AGER, 1956b, Palaeontogr. Soc. Monogr., p. 29–33, pl. 3, figs. 1–4.

Several specimens from the east side of the valley at Yakaçik appear to belong to this familiar west European species, which was recently revised by the present author (Ager, 1956b). One specimen at least is almost identical with the type specimen and others have a slightly wider plication. One example has a second costa developed obliquely on one side of the dorsal fold, comparable to the rarity figured from Dorset (Ager, 1956b, pl. 3, fig. 3a); another specimen has a faint costa on each side of the fold. As only a few specimens are available, the two examples with extra costae (Text-fig. 1) cannot be dismissed as atypical variants, but there are no real grounds for proposing a new species here.

The chief interest which attaches to the finding of this form in Anatolia lies in its horizon and its discontinuous distribution. In the British Isles, *Homoeorhynchia acuta* is the earliest species of the genus but probably does not occur below the Upper Pliensbachian (*i.e.*, the Middle Lias). The genus is, however, known at much lower levels on the European continent, probably as low as the Rhaetian (Ager 1956b) and perhaps lower down in the Trias. It does not appear to have been described previously from outside western Europe and northwest Africa, where it ranges from the Hebrides in the north to Morocco in the south. It is not found in the Tethyan facies of the Lias in areas such as the Austrian Alps, Hungary, north Italy, the Apennines or Sicily. On the other hand, this species is abundant and well developed in Dorset, England, and in Normandy, France, at both of which localities it is accompanied by *Cirpa* and other forms of Tethyan affinities (Ager, 1956a).

Genus CIRPA di Gregorio, 1930
CIRPA KIRAGLIAE Ager, n. sp.
Pl. 128, figs. 2a–c

Rhynchonella variabilis VADASZ (*non* Schlotheim), 1913, Mitt. Jahrb. Kgl. ungar. geol. Reichsanst., v. 21, p. 68.

Medium to large *Cirpa*, up to about 20 mm. long, 24 mm. wide, and 18 mm. thick. Broadly subtrigonal in outline, depressed; 9 to 14 costae on each valve, four to six of which are in the fold. Beak small, incurved. Double deltidial plates widely spaced, hingeplates fused only posteriorly. Dorsal septum very short.

Type-specimen: Holotype, author's collection, Lias, Yakaçik. Specimen in British Museum (Natural History), BB. 21781.

Dimensions of holotype: length 14.6 mm., width 17.8 mm., thickness 10.9 mm.

Discussion.—The little-known genus *Cirpa* was recently revised by the present author (Ager, 1959a). It has certain distinctive external features, notably the replace-

TEXT-FIG. 1—*Homoeorhynchia acuta* (J. Sowerby), Lias, Yakaçik, Turkey. Anterior views of three specimens to show variation in the plication. *Left:* usual form comparable to type specimen; *center:* variant with faint lateral costa on one side; *right:* variant with faint lateral costae on both sides. All ×1, approximately.

both specimens, but appears to be small and upright.

There are several names available which could be justifiably applied to these specimens. The adult is very like forms from the Lower Lias (*semicostatum* and *turneri* zones) of Gloucestershire, England, and similar forms are well known in the Lower Lias throughout northwest Europe. But for the elevation of the fold, the figured specimen is almost identical with the type specimen of '*Rhynchonella*' *thalia* d'Orbigny which is preserved in the *Museum d'histoire naturelle* in Paris. This is particularly interesting because Buckman (1918) made that species the type of another of his genera—*Tropiorhynchia*. This genus was said to be characterized by a distinct 'norella' (*i.e.*, posteriorly sulcate) stage. There is no trace of this on the type specimen and *Tropiorhynchia* is regarded by the present author as a synonym of *Piarorhynchia*. This species was originally recorded by Quenstedt from the Lias α of Germany. Other species of *Piarorhynchia*, all very difficult to distinguish, range in England from the Lower Sinemurian to the Lower Pliensbachian. They occur at the same levels in France and Germany, but are known as high as the Toarcian in Morocco. They are therefore probably of little stratigraphical value.

Family DIMERELLIDAE Buckman, 1918
Genus SULCIROSTRA Cooper & Muir-Wood, 1951

SULCIROSTRA(?) ANATOLICA (Vadasz)

Rhynchonella anatolica VADASZ, 1913, Mitt. Jahrb. Kgl. ungar. geol. Reichsanst., v. 21, p. 67.

Rhynchonellina anatolica VADASZ, *ibid.*, pl. 4, figs 5a–c.

No example of this species was found by the author at Yakaçik and none is preserved in the Turkish collections, but it requires mention because of its special interest. Vadasz described and figured a single specimen from Yakaçik and referred it (at least in his 'explanation of plates') to Gemmellaro's genus *Rhynchonellina*.

Rhynchonellina is strictly 'Tethyan' in distribution and is found in the same areas as *Propygope aspasia* (see below). It is not known in northwest Europe. The costate members of the *Rhynchonellina* group were later separated by Gregorio (1930b) as a new genus *Rhynchonellopsis*, but this was shown to be a junior homonym by Cooper and Muir-Wood and renamed *Sulcirostra*.

In almost all its characters the Turkish specimen closely resembles *Sulcirostra;* its long straight hinge-line and wide delthyrium with rudimentary deltidial plates are particularly clear. Vadasz compared his species with *Rhynchonellina rothpletzi* Böse, and the resemblance is really remarkable but for the all-important character of the fold. Some species of *Rhynchonellina* and *Sulcirostra* are rectimarginate, the majority (including *R. rothpletzi*) are slightly sulcate. *S.(?) anatolica* is clearly uniplicate with a dorsal and not a ventral fold. This is obvious both from the figures and the description, so the species cannot be more than very doubtfully referred to *Sulcirostra*.

Genus HOLCORHYNCHIA Buckman, 1918

HOLCORHYNCHIA? YAKAÇIKENSIS Ager, n. sp.

Pl. 128, figs. 5a–c

Medium-sized depressed rhynchonellid up to about 14 mm. long, 12 mm. wide, and 9 mm. thick. Trigonal in outline, shallow sulcation starting near posterior end. About 14 to 18 fine, blunt costae developed anteriorly. Broad shallow septalium, long median septum, long radulifer-type crura.

Type specimen: Holotype, author's collection, Lias, Yakaçik. Specimen in the British Museum (Natural History), BB. 21784.

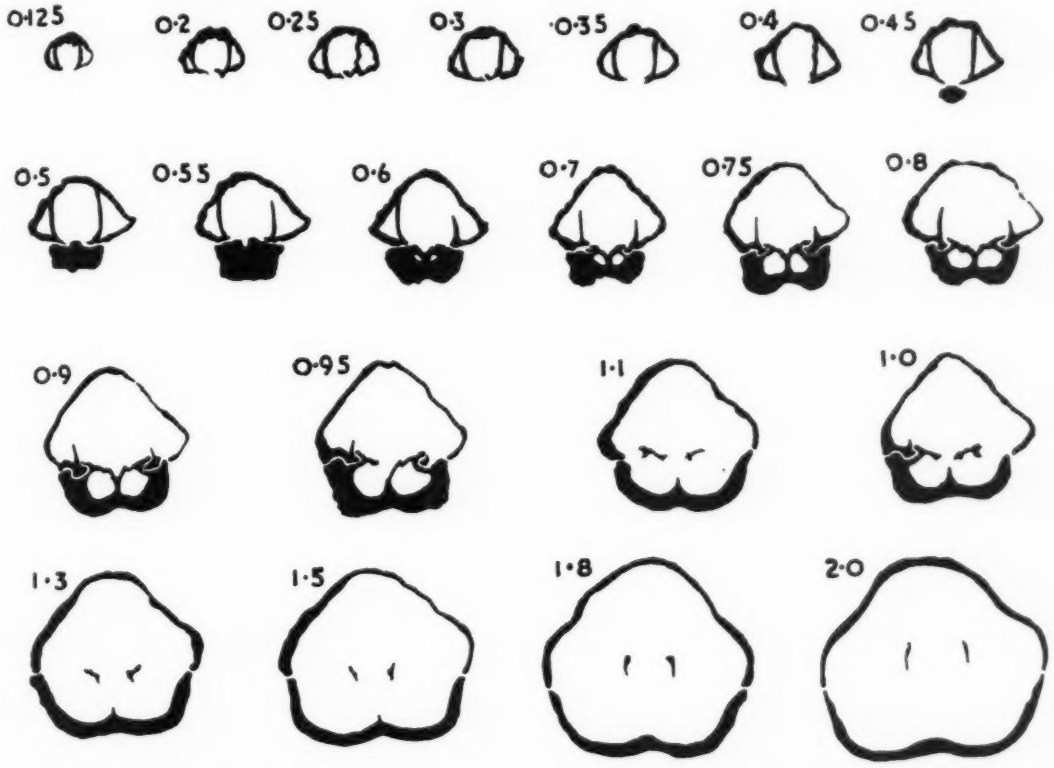
Dimension of holotype: Length 10.1 mm., width 9.8 mm., thickness 6.1 mm.

Discussion.—This species is quite distinctive externally in its trigonal outline. The other species so far recognized in *Holcorhynchia* are circular or subcircular. In this character *H.? yakaçikensis* closely resembles members of the allied genus *Gnathorhynchia* but it differs from them in having a tiny incurved beak and concealed delthyrium. It is perhaps doubtful if these two genera, both erected by Buckman (1918), should be separated. Both are distinguishable by their long posterior smooth stage and by their slight (but clear) sulcation. Buckman recorded *Holcorhynchia* as ranging from the Domerian (Upper Pliensbachian) into the

Toarcian, and *Gnathorhynchia* from the Bajocian to the Callovian. The former may therefore very well be the direct ancestor of the latter. The species under consideration could be a connecting link between the two. It may be significant that Buckman observed of *Gnathorhynchia* (*op. cit.*) that " . . . the later species show more ribs and less dorsal sulcation, . . . " *H.? yakaçikensis* has an obvious sulcation which extends almost to the posterior margin and has only very short ribs; it also far precedes Buckman's *Gnathorhynchia* species in time. No details have previously been published of the internal structure of either *Holcorhynchia* or *Gnathorhynchia*.

A series of transverse sections through a specimen of the species under consideration is shown in Text-figure 4. These show a fairly wide delthyrium with conjunct deltidial plates, a broad shallow septalium supported by a long median septum, and long parallel radulifer-type crura. In a dorsal valve which is 7.6 mm. long, the sulcation can be seen to begin 0.2 mm. from the posterior end.

The author has tentatively suggested elsewhere (Ager, 1959b) that the genera *Holcorhynchia* and *Gnathorhynchia* should be placed in the family Dimerellidae (subfamily Norellinae) on the grounds of their dorsal sulcation, small size, and posterior smoothness. The long crura and median septum shown in Text-figure 4 are also suggestive of this family. However, in view of the anomalous characters of this species, the author only doubtfully refers it to *Holcorhynchia*.



TEXT-FIG. 4—Transverse serial sections of a topotype of *Holcorhynchia? yakaçikensis* Ager, n. sp. The original length of the specimen was 8.0 mm. Distinctive features are the broad shallow septalium seen in the second row of sections, the persistent median septum, and the parallel radulifer-type crura seen in the bottom row. The median sulcation in the dorsal valve is clearly visible. The crura finally disappeared at 2.25 mm. from the posterior end. Author's collection J. 1076/3. All ×7, approximately.

Family TEREBRATULIDAE Gray, 1840
Genus PROPYGOPE Bittner, 1890
PROPYGOPE ASPASIA Meneghini
Pl. 128, figs. 6a–c

Terebratula aspasia MENEGHINI, 1854, Ann. Univ. Toscana, v. 3, p. 13;—, 1867, Paléont. Lombarde, p. 168, pl. 31, figs. 8,9.
Terebratula aspasia var. *minor* ZITTEL, 1869, Geogn. Palaeont. Beiträge, p. 38, pl. 14, figs. 3a–d.
Terebratula (*Pygope*) *aspasia* RENZ, 1932, Abh. schweiz. palaeont. Gesell., v. 52, p. 28, pl. 2, figs. 5–5b.
Glossothyris aspasia var. VIGH, 1943, Földtani Közlöny, v. 73, p. 333, pl. 25, figs. 23–28.

Two specimens from Yakaçik, one of them a juvenile, are referable to this distinctive species. It is a strongly sulcate (*i.e.*, inverted) terebratulid, the plication being rounded and the ventral fold slightly raised. The beak is massive, but not keeled like *Aulacothyris* and without sharp beak-ridges. The large, circular, permesothyrid foramen and the absence of any signs of a dorsal median septum show that this is a short-looped terebratuloid. A very wide, low delthyrium is just visible below the beak in the adult specimen, as are two narrow, disjunct deltidial plates.

These specimens are very close to the unnamed new variety distinguished by Vigh (1943), but there is no point in a new name. In the magnitude of the fold, the Turkish form is perhaps closer to the closely allied species '*Terebratula*' *nimbata* and '*T.*' *beyrichi* (both proposed by Oppel in his 1861 paper), but it can be distinguished from these by the rounded nature of the sulcation.

The *aspasia* group of Liassic sulcate terebratulids is often attributed to the genera *Pygope* or *Glossothyris* (which was shown by Buckman, 1918, to be a synonym of *Nucleata*). These are both late Jurassic sulcate terebratulids, the former including the famous series of perforate species. There is no evidence of a connection between these and the Lower Jurassic forms, and practically nothing has been published on their internal structures. The only Liassic sulcate form for which internal details have been published is '*Terebratula*' *reversa* Ager, from the Middle Lias of the Dorset coast (1957). This, however, differs markedly from the '*T.*' *aspasia* group in external appearance. It is suggested that these forms are probably referable to Bittner's genus *Propygope*, which was erected as a subgenus of *Terebratula* for very similar forms from the Alpine Upper Trias.

The geographical distribution of Liassic sulcate terebratulids is particularly interesting. Inverted terebratulids and rhynchonellids are characteristic of Lower Jurassic faunas in Italy, Sicily, Austria, Hungary, possibly Yugoslavia, and Greece. Elsewhere they are very rare. In Britain, the author has found inverted terebratulids only in one thin bed at the top of the Middle Lias on the Dorset coast (Ager, 1956a). There they were accompanied by other species of southern aspect, notably a species of *Cirpa*.

It seems reasonable to suppose that sulcate terebratulids are very rare in the Turkish Lias, as they are in England. It is interesting to note that *Propygope aspasia* at Yakaçik is accompanied by the same genera which are found with '*Terebratula*' *reversa* in Dorset. It may also be significant that this is the only short-looped terebratulid to be found in the Yakaçik fauna, though Vadasz did record two specimens of '*Terebratula*' *punctata* Sowerby and one of the '*Terebratula*' cfr. *erbaensis* Suess.

Stratigraphically *Propygope aspasia* appears to range from the Upper Sinemurian to the Upper Pliensbachian. Vigh (1943) recorded the variety quoted in the synonymy from the Lias β (*i.e.*, Upper Sinemurian).

Family ZEILLERIIDAE Allan, 1940
Genus ZEILLERIA Bayle, 1878
ZEILLERIA LYCETTI (Davidson)
Pl. 129, figs. 2a–c

Terebratula lycettii DAVIDSON, 1851, Palaeontogr. Soc. Monogr., p. 44, pl. 7, figs. 17–19 (only).
Zeilleria lycettii ROLLIER, 1919, Abh. schweiz. palaeont. Gesell., v. 44, p. 295.

Probably the commonest species at Yakaçik is this depressed, rectimarginate zeilleriid with a curved (non-truncate) anterior margin. Many names have been given to forms of this type in the European Lias, most of which are almost certainly conspecific. The name given in any particular case depends largely on the nationality and personal idiosyncrasies of the author. I therefore choose here a name of British authorship which has been widely used in the British Lias. This appears to have been

a stable species, lacking in distinctive characters, which remained static at least throughout Liassic times. It is quite useless from the stratigraphical point of view.

ZEILLERIA INDENTATA (J. de C. Sowerby)
Pl. 129, figs. 3a–c

Terebratula indentata J. DE C. SOWERBY, 1824, Mineral Conchology, v. 5, p. 65, pl. 445, fig. 2; DAVIDSON, 1851, Palaeontogr. Soc. Monogr., p. 446–447, pl. 5, figs. 25,26.
Zeilleria indentata ROLLIER, 1919, Abh. schweiz. palaeont. Gesell., v. 44, p. 298.

A few small specimens were found on the east side of the valley at Yakaçik which can be attributed to this species, though there are several other names in later literature which are equally applicable. They are typical rectimarginate zeilleriids with an indentate anterior margin. They have a greater proportional width than the specimens figured by Sowerby, but are probably well within the range of variation observed in British Middle Liassic specimens. Like the forms here attributed to *Zeilleria lycetti* (Davidson), they have probably no stratigraphical significance.

This is probably the form which Vadasz (1913) referred to as '*Waldheimia subdigona* Oppel,' but that species is merely truncate anteriorly and not indentate.

Genus CINCTA Quenstedt, 1868
CINCTA NUMISMALIS (Lamarck)
Pl. 129, figs. 4a–c

Terebratula numismalis LAMARCK, 1819, Animaux sans vertébres, v. 6, p. 334; ZIETEN, 1830–33, Pétrifications de Wurtemburg, p. 52, pl. 39, figs. 5a–c; DAVIDSON, 1851, Palaeontogr. Soc. Monogr., p. 36, pl. 5, figs. 4–9.
Cincta numismalis BUCKMAN, 1907, Proc. Cotteswold Nat. F.C., p. 40, pl. 6, figs. 5,6 (and probably all the other 19 'species' figured except *C. cor*).

Only six small specimens were found of this characteristic flat zeilleriid of the Lower Lias. There seems to be no reason not to attribute the Yakaçik form to the Lamarck /Valenciennes species, though it could easily be fitted into one or several of the unnecessary 'species' named by Buckman (1907). These are all merely slight shape variants collected from the same horizon and locality. Most zeilleriid species show a comparable range of variation.

Genus AULACOTHYRIS Douvillé, 1879
AULACOTHYRIS cf. A. RESUPINATA
(J. Sowerby)
Pl. 129, figs. 5a–c

Terebratula resupinata J. SOWERBY, 1816, Mineral Conchology, v. 2, p. 116, pl. 50, figs. 3,4; DAVIDSON, 1851, Palaeontogr. Soc. Monogr., p. 31, pl. 4, figs. 1–5.
Aulacothyris resupinata DOUVILLÉ, 1879, Bull., Soc. Géol. France, v. 7, p. 277, fig. 19; ROLLIER, 1919, Abh. schweiz. palaeont. Gesell., v. 44, p. 344.

This is a fairly small, broad *Aulacothyris* with a broad shallow sulcation. It is like *A. resupinata* as originally figured by Sowerby but for the shallowness of the ventral fold and the absence of a sharp groove in the dorsal valve. In Britain *A. resupinata* (which is the type species of the genus) is entirely restricted to the *spinatum* Zone (Upper Pliensbachian).

AULACOTHYRIS ANATOLICA (Vadasz)
Pl. 129, figs. 1a–c

Waldheimia anatolica VADASZ, 1913, Mitt. Jahrb. Kgl. ungar. geol. Reichsanst., v. 21, p. 69, figs. 6a–d.

This is a medium to large-sized *Aulacothyris*, elongated and with a broad, shallow sulcation in the dorsal valve. It is close to *A. pyriformis* (Tate) from the *spinatum* Zone of north Yorkshire, but may be distinguished from that species by its less globose nature and by its greatest width being near the anterior end of the shell. Tate's original figure (Tate & Blake, 1876, pl. 15, fig. 12) suggests the latter character in his species also, but this is largely a matter of orientation of the specimen for the illustration. All the specimens of *A. pyriformis* seen by the author have their maximum width about half-way between the anterior and posterior margins. The present species was well illustrated by Vadasz (1913) showing the diagnostic characters.

Though zeilleriid species are notoriously variable in external characters, there appears to be no gradation between this species and the one just described. The latter may be regarded as *Aulacothyris* s.s., while the species described here belongs to a distinct group which includes also *A. pyriformis* (Tate) and *A. fusiformis* (Rollier). It has been suggested that this group should be made a new genus, though this hardly

seems to be justified on external features. It is interesting to note that whereas in Britain the two aulacothyrid groups are geographically separated (Ager 1956a), in Turkey they occur together. This may be taken as support for their generic distinction, but one cannot be sure that they occur at precisely the same horizon.

Family SPIRIFERINIDAE Davidson, 1884
Genus SPIRIFERINA d'Orbigny, 1847
SPIRIFERINA sp. indet.

Six poorly-preserved specimens of *Spiriferina* were found on the east side of the valley at Yakaçik. These were smooth, rectimarginate forms, with occasional well-marked growth-lines. They have large interareas which are set almost at right angles to the commissure; the beaks are massive and somewhat incurved. Only one specimen appeared to be fully developed and this was too damaged for specific determination. In northwest Europe they would probably be referred to *Spiriferina rostrata* (Schlotheim), which is particularly characteristic of the *jamesoni* Zone, but several other names are equally defendable.

OTHER TURKISH FAUNAS

Liassic brachiopod faunas are known from a few other localities in Turkey and the author was able to examine collections from these at Ankara and Istanbul. A particularly large fauna is preserved at the Maden Tetkik ve Arama Enstitüsü in Ankara, from Gümüshane-merkez, near Reksene in the northeast of the country, south of Trabzon. This is comparable to the Yakaçik fauna and is dominated by the rhynchonellid *Cirpa kiragliae* (see above). The following forms were identified by the author:

Cirpa kiragliae Ager, n. sp.
Homoeorhynchia acuta (J. Sowerby)
Piarorhynchia deffneri (Oppel)
Cuneirhynchia dalmasi (Dumortier)
Lobothyris punctata (J. Sowerby)
Zeilleria quadrifida (Lamarck)
Zeilleria lycetti (Davidson)
Zeilleria indentata (J. de C. Sowerby)
Zeilleria subdigona (Oppel)
Aulacothyris cf. *A. resupinata* (J. Sowerby)
Aulacothyris anatolica (Vadasz)
Spiriferina rostrata (Schlotheim)

This list includes a few forms not found or recorded at Yakaçik, but all these are of northwest European type.

Alpine-type forms such as *Sulcirostra? anatolica* (Vadasz) and *Propygope aspasia* (Meneghini) are noticeably absent from this fauna, though Otkun (1942) did record a single specimen of the latter from the neighboring locality of Bayburt. This specimen could not be found with the rest of his collection at Ankara. Otherwise, the fauna at Bayburt seems to be very like that at Reksene.

A few specimens were also seen from Lodumu, about 12 km. southwest of Ankara. These included a well-preserved specimen of *Prionorhynchia serrata* (J. de C. Sowerby), almost identical with one of the variants figured by the present author from Britain (1956b, pl. 2, figs. 12a–c). *Prionorhynchia* is curiously uncommon in the Turkish collections, though its usual associates (as in the Middle Lias on the Dorset coast) are plentiful. This may however be a matter of stratal failure since it is only known for certain in the upper part of the

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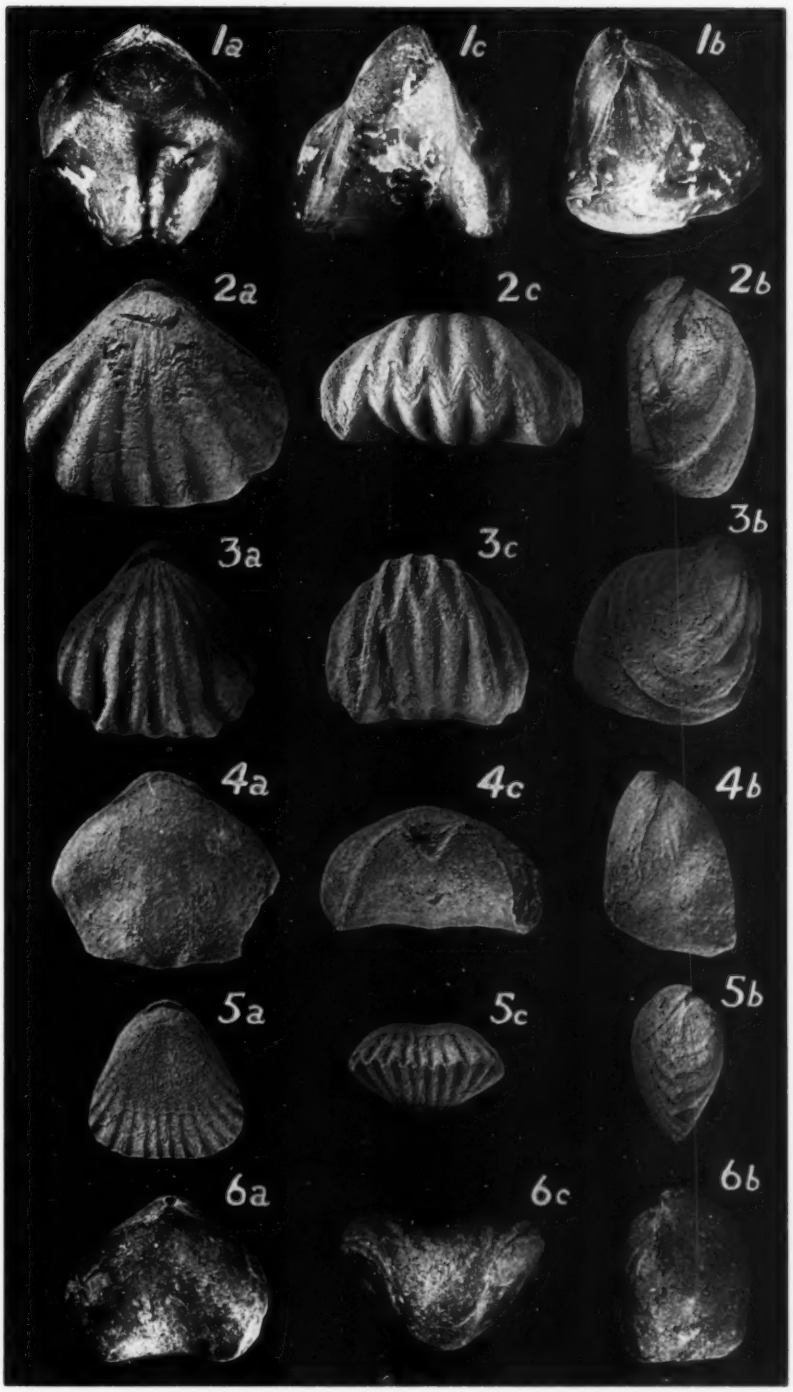
EXPLANATION OF PLATE 128

In each case '*a*' is the dorsal view, '*b*' the lateral view, and '*c*' the anterior view with the dorsal valve uppermost. All the specimens were sprayed with ammonium chloride before photographing, except the first and last specimens which show the natural appearance of the shells. BM(NH) = British Museum (Natural History). All the specimens are from the Lower Jurassic of Yakaçik, near Ankara, Turkey.

FIGS. *1a–c—Homoeorhynchia acuta* (J. Sowerby). BM (NH) BB. 21780, ×2.
2a–c—Cirpa kiragliae Ager, n. sp. Holotype, BM (NH) BB. 21781. ×2.
3a–c—Cirpa kiragliae globosa Ager, n. subsp. Holotype, BM (NH) BB. 21782, ×2.
4a–c—Piarorhynchia deffneri (Oppel). BM (NH) BB. 21783, ×2. This specimen was from the west side of the valley; all the others were from the east side.
5a–c—Holcorhynchia? yakaçikensis Ager, n. sp. Holotype, BM (NH) BB. 21784, ×2.
6a–c—Propygope aspasia (Meneghini). BM (NH) BB. 21785, ×2.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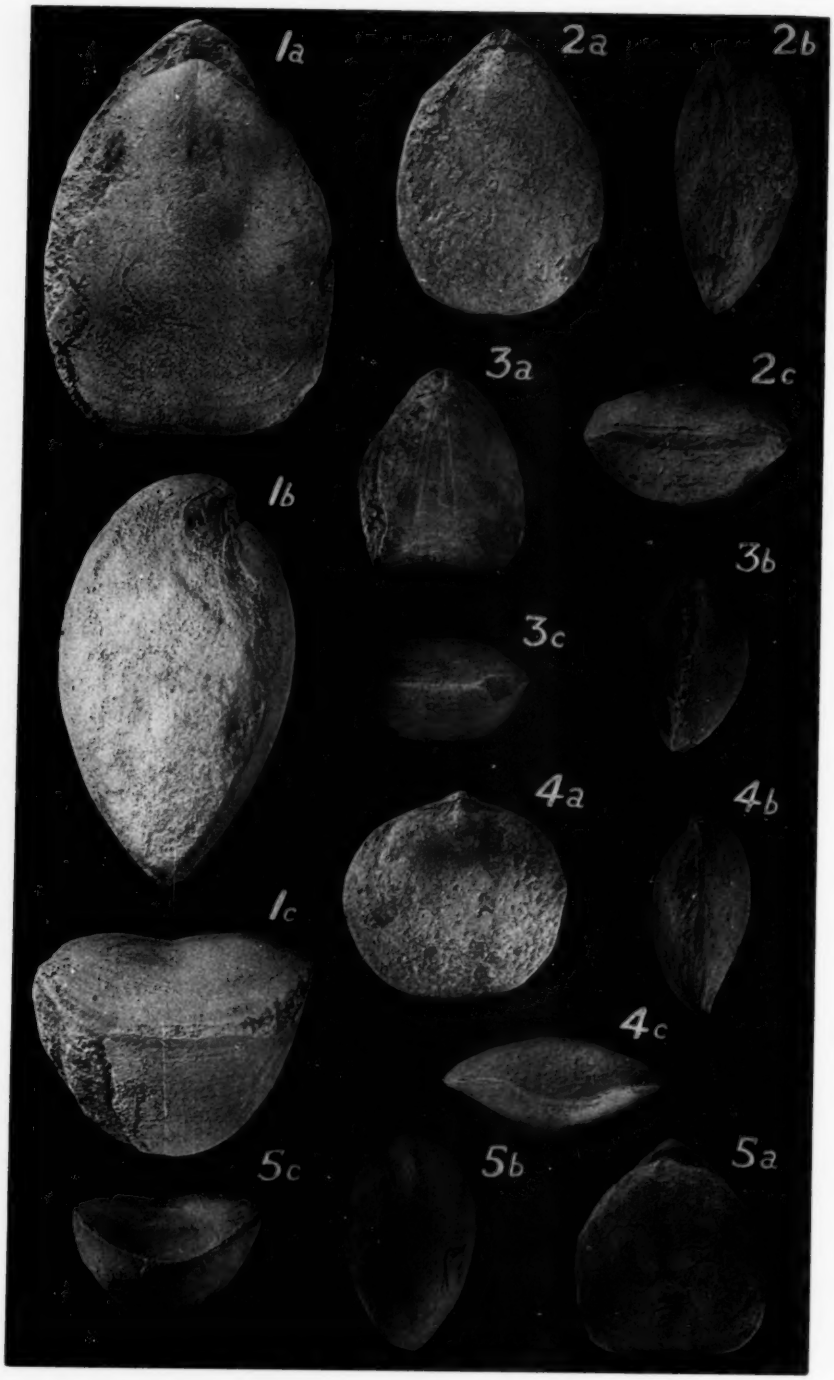
1a
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5a

Upper Pliensbachian (*i.e.*, in the *spinatum* Zone), and this may not be present at the other Turkish localities discussed. The other genera probably have a longer range.

GENERAL AFFINITIES OF THE YAKAÇIK FAUNA

In the prejudiced opinion of the writer, the most interesting feature of the Yakaçik fauna is its strong affinities with the faunas of western Europe. Almost without exception, the Turkish brachiopods are the same as, or very close to, species known in the British Lias, especially species characteristic of Dorset and Somerset. The brachiopods as a whole suggest a slightly later age than do the associated ammonites (Upper Sinemurian-Upper Pliensbachian compared with Lower-Upper Sinemurian). If the earlier date is to be accepted then this may be significant in connection with the directions of brachiopod migration. The absence of the widespread genus *Prionorhynchia* may be important in this connection, since it is a useful index fossil for the uppermost Pliensbachian.

Though the vast bulk of the brachiopod fauna is of northwest European 'shelf-sea' type, there are rare elements suggesting the Alpine or 'Tethyan' facies. These are *Propygope aspasia* and *Sulcirostra? anatolica*, which are obviously very rare and may be at the extreme limit of their range.

ADDENDUM

Since writing the above, the author has been able to examine the major part of Professor Vadasz's collection from Yakaçik at the Hungarian Geological Institute in Budapest. This served to confirm the identifications recorded above with the addition of the ubiquitous species *Lobothyris punctata* (J. Sowerby) and *Spiriferina alpina* (Oppel). These were both represented by only a very few specimens. The author also noted specimens of *Homoeorhynchia acuta* from the Transylvanian Lias of Roumania, which forms a connecting link in the geographical distribution discussed above.

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EXPLANATION OF PLATE 129

All the specimens are from the Lower Jurassic of Yakaçik, near Ankara, Turkey.

FIGS. *1a–c—Aulacothyris anatolica* (Vadasz). BM (NH) BB. 21786, ×2.
2a–c—Zeilleria lycetti (Davidson). BM (NH) BB. 21787, ×2.
3a–c—Zeilleria cf. *indentata* (J. de C. Sowerby). BM (NH) BB. 21788, ×2.
4a–c—Cincta numismalis (Lamarck). BM (NH) BB. 21789, ×2.
5a–c—Aulacothyris cf. *resupinata* (J. Sowerby) BM (NH) BB. 21790, ×2.

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JOURNAL OF PALEONTOLOGY, V. 33, NO. 6, P. 1029–1068, PLS. 130–133, 1 TEXT-FIG., NOVEMBER, 1959

THE AMERICAN UPPER ORDOVICIAN STANDARD. I. EDEN CONODONTS FROM THE CINCINNATI REGION OF OHIO AND KENTUCKY

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ABSTRACT—A conodont fauna of 36 species is described from the Eden formation of southwestern Ohio and adjacent areas in Kentucky. Representatives of *Belodina compressa, Cordylodus delicatus, C. flexuosus, Drepanodus homocurvatus, D. suberectus, Oistodus abundans, O. inclinatus, Ozarkodina robusta, Phragmodus undatus, Prioniodina oregonia*, and *Zygognathus deformis* dominate the Eden fauna. Species of *Ambalodus, Keislognathus, Prioniodus, Sagittodontus*, and *Scolopodus* occur in the lower Eden, but they decline in abundance or are absent in the upper Eden. A similar "mixture" of provincial indicators characterizes the late Galena Stewartville and Dubuque of Iowa and the Gelli-grin and Pen-y-garnedd limestones of Wales, now thought to be Eden equivalents, at least in part.

The genus *Eobelodina* and five species (*Cordylodus excavatus, Prioniodina rotunda, Prioniodus*, n. sp., *Trichonodella angulata*, and *T. subundulata*) are described for the first time.

INTRODUCTION

THE remarkably fossiliferous bluish green shales and limestones that crop out in southwestern Ohio and adjacent areas of Indiana and Kentucky are the reference section for the Upper Ordovician Cincinnatian Series of North America. It is important that our knowledge of the distribution of all the fossil groups in these strata be periodically enlarged and revised so that other parts of the Cincinnatian Series can be more critically compared with them. For this reason, the writers, in cooperation with others at The Ohio State University and the University of Cincinnati, have undertaken a re-examination of the standard section in the Cincinnati region. In the process of this restudy, we expect to undertake detailed lithostratigraphic investigations, and to revise and broaden our knowledge of the taxonomy, occurrence, and stratigraphic distribution of the many groups represented by fossils in the type strata. The present paper is the first in a projected series of contributions toward these ends.

Although the disjunct parts of conodonts ("conodont-elements") are common microfossils in Upper Ordovician rocks in North America and Europe, proper stratigraphic evaluation of known faunas is hampered by the fact that there has been little written concerning the distribution of conodonts in the standard section of the Cincinnatian Series. In 1884, U. P. James described two species of conodonts from the Cincinnatian, near Cincinnati. One of these, *Prioniodus dychei*, is probably a *Trichonodella* and the specimens referred to this species by James were collected from both Eden and Richmond strata. The other species, *Polygnathus wilsoni*, is unrecognizable from James' illustration of its type. It seems to have come from rocks in the Richmond group.

Branson & Branson (1942) note that conodonts occur throughout the typical Cincinnatian in Kentucky and adjacent states and remark as to the general nature and relationships of the several faunas they recognized. However, detailed descriptions were provided (Branson, Mehl, & Branson, 1951) only for the forms collected from the upper Cincinnatian Richmond group of Kentucky and Indiana.

Strata referred to the Covington group (Eden, Fairview, and McMillan formations) in the Cincinnati region also contain rich and varied conodont faunas, and these may prove to be of considerable value in the stratigraphic evaluation of Cincinnatian strata outside the Cincinnati region. Consequently, we believe that these conodonts merit detailed description and illustration.

We hope that this report on Eden conodonts and the description of Richmond group forms prepared by Branson, Mehl, & Branson (1951) will aid students of the Ordovician in other parts of North America to correlate Cincinnatian strata in a more precise way than is now possible.

We are pleased to acknowledge the help, in field and laboratory, of our colleagues at The Ohio State University, Professors Mildred F. Marple and Malcolm P. Weiss, and at the University of Cincinnati, Professors Kenneth C. Caster and William F. Jenks. We have discussed taxonomic problems with Dr. Maurits Lindström, of Lunds University, Sweden, Professor Frank H. T. Rhodes, of the University College of Swansea, Wales, Professor M. G. Mehl, of the University of Missouri, Professor W. M. Furnish, of the State University of Iowa, and Professor Raymond L. Ethington, of Arizona State College. We are indebted to them for their counsel and assistance. The Graduate School of The Ohio State University granted funds that made it possible for us to prepare the plates that accompany this report.

STRATIGRAPHY

Several reports (Nickles, 1902, 1903; Foerste, 1905; Bassler, 1906; Cumings, 1908, 1922; Fenneman, 1916; Gutstadt, 1958) include accounts of the history of stratigraphic concepts and nomenclature in the Cincinnati region, hence these are not reviewed here. It should perhaps be pointed out that there is general agreement as to how the local section should be subdivided into formational units, but there appear to be differences in opinion as to how these formations should be named and grouped into larger units.

If the reference section of the Cincinnatian, in the Cincinnati region, be considered to include all those strata between the Point Pleasant (Cynthiana) beds and the Brassfield and their lateral equivalents, it is possible to recognize eight reasonably distinct formational units in the sequence. In ascending order, these are the Eden, Fairview, McMillan, Arnheim, Waynesville, Liberty, Whitewater, and Elkhorn formations. The Eden formation may be considered the reference standard for an early Cincinnatian Eden Stage; the Fairview and McMillan formations constitute the standard for a medial Cincinnatian Maysville Stage; the Arnheim, Waynesville, Liberty, Whitewater and Elkhorn formations define the Richmond Stage of the Cincinnatian. We prefer to follow Bassler (1906) in grouping Eden, Fairview, and McMillan *rocks* into a local Covington group, which, consequently, contains the standard sections of both the Eden and Maysville stages.

The conodont-elements described in this report were collected from strata of the Eden formation of the Covington group. Following Fenneman (1916), many students of the Cincinnatian have recognized an Eden group, composed of the Fulton and Latonia formations. However, Caster, Dalve, & Pope (1955) seem to regard the names Eden and Latonia as synonyms, for, in their pamphlet they indicate that both units contain the same strata at Cincinnati. Foerste (1905) proposed the name "Fulton beds" for the dark strata with *Triarthrus* immediately above the Point Pleasant (Cynthiana) beds at and near Cincinnati. These beds, some five feet thick and no longer exposed in Cincinnati, appear to disappear westward but to thicken somewhat eastward from Cincinnati. The Fulton beds are not easy to distinguish lithologically, even though they are supposed to be "dark shales," hence we believe that they should be included with the lower member of the Eden formation.

The Eden formation has been divided into three members, in ascending order, the Economy (including the basal Fulton beds), Southgate, and McMicken. These units were originally recognized (Nickles, 1902) on the basis of their contained bryozoans, the Fulton-Economy characterized as the "*Aspidopora newberryi* beds," the Southgate as the "*Batostoma jamesi* beds," and the McMicken as the "*Dekayella ulrichi* beds." Geographic names were applied by Bassler (1906).

The Economy member (which we will designate "Fulton-Economy" in this report), named for Economy (now West Covington), Kentucky, consists of 20 to 80 feet of thinly interbedded bluish to brownish gray shales, and grayish white lime-

stones. Unweathered shales are compact, calcareous, and exhibit little lamination, whereas leached shales are distinctly fissile. The shale beds seem to be relatively uniform in composition, but some units contain considerable quantities of silt-size quartz and feldspar, and presumably authigenic gypsum, pyrite, and limonite. The shales yield an abundant microfauna but are, for the most part, relatively barren of macrofossils. Fulton-Economy limestones are thinner and less numerous than shale units; however, they are more resistant to weathering than the shales and form prominent ledges in weathered exposures. A majority of the Fulton-Economy limestones are relatively coarse-grained and seem to be composed mostly of the comminuted remains of bryozoans and brachiopods, and the upper surfaces of several thicker units are rather coarsely ripple-marked. Several layers are essentially unfossiliferous; these layers are thin and dense, and their residues contain considerable amounts of fine quartz sand.

Megafossils are uncommon in Fulton-Economy shales, but limestones contain a wealth of specimens, most of which, however, are incomplete and exhibit considerable wear. Bryozoa, referable to *Batostoma*, *Hallopora*, *Stomatopora*, and *Aspidopora*, are the most abundant megafossils in the Fulton-Economy, but trilobites (*Cryptolithus*, *Isotelus*) are not uncommon and the brachiopods *Resserella* and *Sowerbyella* occur in large numbers in some limestones. We have also collected a number of orthoceraconic nautiloids, probably referable to *Orthonybyoceras*, from the Fulton-Economy. The microfauna consists mostly of conodonts, but we have also collected ostracods and scolecodonts from the shales. Pyritized juvenile gastropods and brachiopods are numerous in limestone residues.

The Fulton-Economy member is gradationally overlain by the Southgate member, named from typical exposures in the vicinity of Southgate, Campbell County, Kentucky (Bassler, 1906). The Southgate includes some 120 feet of alternating bluish gray shale and light gray limestone, distinguished primarily from the subjacent Fulton-Economy and the overlying McMicken by the fact that shales are relatively thicker and limestones, although individually as much as a foot thick, are less numerous. Insofar as our studies permit a comparison, the lithologies of Southgate shales and limestones are similar to those of the Fulton-Economy. In the lower part of the member, there are several prominent limestones bearing coarse ripple-marks on their upper surfaces.

The Southgate is faunally similar to the Fulton-Economy below and the McMicken above; it may be distinguished by its greater content of *Batostoma* and, near the top of the member in at least some sections, there is said (Caster, Dalve, & Pope, 1955, and others) to be a "recurrence" of the *Triarthrus* fauna.

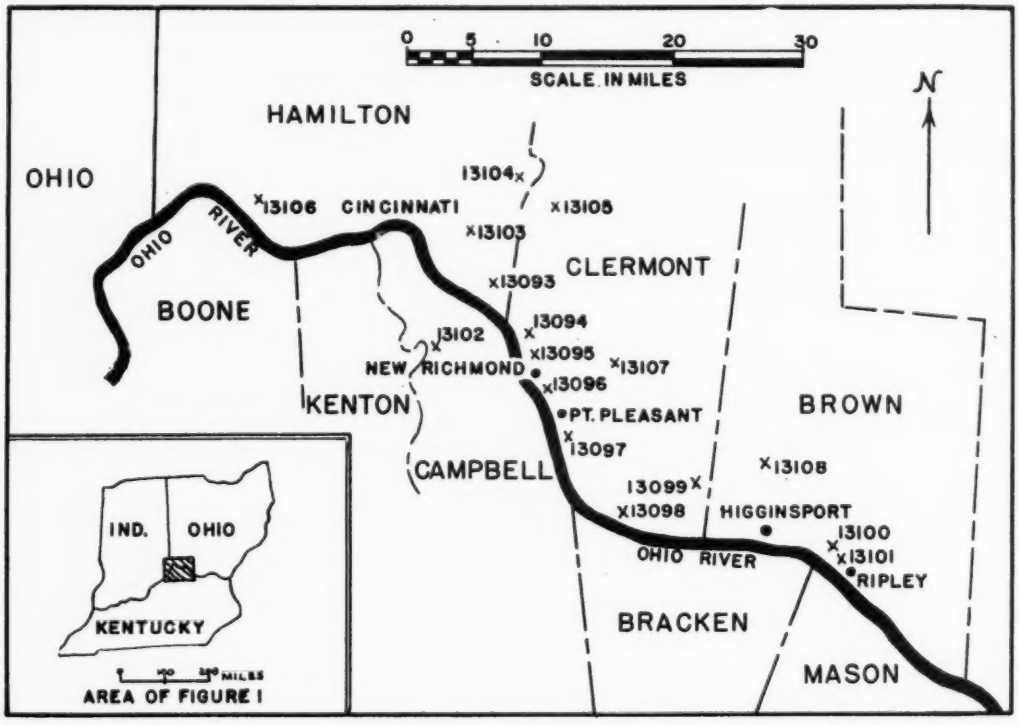
The uppermost Eden member, the McMicken, was named for exposures along McMicken Avenue in Cincinnati. The member is 60 to 70 feet thick and, like the Fulton-Economy and Southgate, consists of a sequence of interbedded bluish gray shale and light blue-gray to gray limestone. The ratio of shale to limestone in the McMicken varies both laterally and vertically, ranging from 3:1 to 10:1 in the same section and along the strike. Shale, however, is invariably preponderant over limestone. Fossils are rare in shale beds; most limestones, however, contain large amounts of fossil debris, much of which is unidentifiable.

Dekayella ulrichi is characteristic of the McMicken and occurs in profusion at all levels in most sections studied. *D. ulrichi* also occurs in the Fulton-Economy and Southgate, hence its presence, even in abundance, in the McMicken renders it of only minor significance in defining stratigraphic boundaries in the field. This species does not, however, continue into the Fairview, hence the level of its disappearance in a given section is a rather reliable stratigraphic datum. *Hallopora onealli* is common throughout the McMicken and is present throughout the Eden. *Batostoma jamesi* is fairly common in the McMicken and seems to be more characteristic of the underlying Southgate. *Constellaria florida* occurs in a thin zone near the top of the McMicken. The brachiopods *Sowerbyella* and *Resserella* are represented by numerous individuals; commonly, one or the other covers the top of a limestone bed to the exclusion of other fossils. *Rafinesquina* and *Zygospira* are less

common but are by no means rare. *Resserella*, *Rafinesquina*, and *Zygospira* have representatives in the balance of the Eden and in the formations above; *Sowerbyella* occurs in the Economy and Southgate, but not in immediately overlying Fairview beds. *Hebertella* is rare in the McMicken, but common in superjacent formations. *Cryptolithus* is distinctive and characteristic of the Eden and older formations. *Calymene* and *Isotelus* are abundant in the McMicken and throughout standard Cincinnatian formations. *Climacograptus typicalis* occurs in great abundance at certain levels in the McMicken and in the underlying Southgate.

METHODS OF COLLECTING AND STUDY

Detailed sections of Eden strata were measured at sixteen places in southwestern Ohio and north-central Kentucky (Text-fig. 1), and approximately 500 gm. samples of fresh unweathered material were collected from each lithologic unit in all sixteen sections. Shale samples were soaked in cold water for about two days to reduce them to soft mud. This mud was then agitated with more water in a Campbell microfossil washer (Campbell, 1951) for two to three hours and the resulting finely divided suspension flushed through nested #60 and #100 micropaleontological sieves. The residues, representing only a small fraction of the original sample, were examined at relatively low magnification under a binocular microscope and all conodonts found in them were removed to covered storage slides with a moistened sable-hair brush. Samples from several limestone units were dissolved by prolonged digestion in 15–20% formic acid and the resulting residues searched in the manner outlined above. By and large, this proved to be an expensive and time-consuming process and, in view of the fact that most shales contained rich conodont associations, it was felt that our collections would



TEXT-FIG. 1—Outline map of the Cincinnati region of Ohio, Kentucky, and Indiana, showing Eden conodont localities.

not be significantly enriched, except in numbers, by digesting samples from all limestone beds.

Application of these procedures resulted in a collection of about 10,000 identifiable conodont-elements, a collection that we believe to be taxonomically as well as statistically representative of the overall Eden conodont fauna.

OHIO-KENTUCKY EDEN CONODONT LOCALITIES

Conodonts described in this report were collected from Eden strata measured and sampled at the following localities (Text-fig. 1). Measured sections are on file with the Ohio Geological Survey, The Ohio State University, Columbus. Locality numbers are O.G.S. file, or section numbers.

Locality 13093.—Eightmile Creek, Anderson Township, Hamilton County, Ohio. Measured section includes 199 feet of Eden strata, including Fulton-Economy, Southgate, and McMicken members. Section continuous, subdivided into 166 sampled units. Section begins at Point Pleasant-Eden contact, near mouth of Eightmile Creek, about 6 miles northwest of New Richmond, Ohio, and continues up creek and tributaries to about a mile southeast of Asbury, Ohio.

Locality 13094.—Nine Mile Creek, about 5 miles northwest of New Richmond, Pierce Township, Clermont County, Ohio (East Cincinnati, Ohio, quadrangle). Only Fulton-Economy member measured here; section 35 feet thick, probably incomplete; subdivided into 50 units, each of which was sampled.

Locality 13095.—Twelve Mile Creek, 2 miles northwest of New Richmond, Ohio Township, Clermont County, Ohio (Alexandria, Ohio-Kentucky, quadrangle). Approximately 40 feet of the Fulton-Economy member are exposed; divided into 50 units, each of which was sampled.

Locality 13096.—First stream valley northwest of Opossum Hollow, northwest of Point Pleasant, Ohio, along U. S. Route 52. Monroe Township, Clermont County, Ohio (Felicity, Ohio-Kentucky, quadrangle). Section includes 58 feet of Fulton-Economy; divided into 102 sampled units.

Locality 13097.—Indian Creek. Section begins at Point Pleasant-Eden contact about 3 miles southeast of Point Pleasant, Washington Township, Clermont County, Ohio (Felicity, Ohio-Kentucky, quadrangle) and continues up Indian Creek. Section includes 87 feet of Fulton-Economy and lower Southgate members; divided into 87 units, each of which was sampled.

Locality 13098.—Stream bed adjacent to Ohio Route 222, about 0.5 mile north of Chilo, Franklin Township, Clermont County, Ohio (Felicity, Ohio-Kentucky, quadrangle). At this place, some 42 feet of Fulton-Economy are exposed. Section divided into 100 sampled units.

Locality 13099.—Slickaway Run. About 4 miles southeast of Felicity, Franklin Township, Clermont County, Ohio (Felicity, Ohio-Kentucky, quadrangle). This section, measured on two separate occasions, was divided into 255 sampled units and includes the Fulton-Economy, Southgate, and lower McMicken.

Locality 13100.—Kope Hollow Branch. Four-tenths of a mile east of Levanna, on U. S. Route 52, Union Township, Brown County, Ohio (Higginsport, Ohio-Kentucky, quadrangle). At this place, a more or less continuous section, including 184 feet of Eden, is exposed. Fulton-Economy, Southgate, and a few feet of the lower McMicken were measured. Section divided into 245 sampled units.

Locality 13101.—Stream bed adjacent to U. S. Route 52, 1.5 miles northewst of Ripley, Union Township, Brown County, Ohio (Higginsport, Ohio-Kentucky, quadrangle). Section includes 40 feet of Fulton-Economy; divided into 81 sampled units.

Locality 13102.—Riffle Creek, 0.5 mile northwest of Alexandria, Campbell County, Kentucky, along Kentucky Route 10 (Alexandria, Kentucky-Ohio, quadrangle). Section includes about 41 feet of Fulton-Economy; divided into 61 sampled units.

Locality 13103.—Unnamed east-flowing tributary of Cluff Creek, about 1 mile southeast of Mt. Washington (Cincinnati), Anderson Township, Hamilton County, Ohio (East Cincinnati, Ohio, quadrangle). Section 60 feet thick; includes 46 sampled units, the lower 26 of which are upper Southgate, the balance lower McMicken.

Locality 13104.—Unnamed stream flowing parallel to Galbraith Road, about 1 mile northwest of Milford, Columbia Township,

Hamilton County, Ohio (East Cincinnati, Ohio, quadrangle). Section 50 feet thick; divided into 39 units, all of which belong in the McMicken member. Each unit sampled.

Locality 13105.—Happy Hollow, 2.5 miles southeast of Milford, Union Township, Clermont County, Ohio (East Cincinnati, Ohio, quadrangle). At this place, 104 feet of Eden are exposed. Section divided into 90 sampled units belonging in the upper part of the Southgate and lower part of the McMicken.

Locality 13106.—Lower Rapid Run, 5.5 miles west of Sedamsville on U. S. Route 52, Delhi Township, Hamilton County, Ohio (West Cincinnati, Ohio, quadrangle). This section includes part of the Fulton-Economy and complete sections of the Southgate and McMicken members. Only the upper two were measured. Aggregate thickness of Southgate and McMicken, about 170 feet; divided into 86 units.

Locality 13107.—Twelvemile Creek and Ferguson Run, Monroe Township, Clermont County, Ohio (Felicity, Ohio-Kentucky, quadrangle). Section 165 feet thick, including complete Southgate and McMicken members. Subdivided into 97 units, each of which was sampled.

Locality 13108.—"White Swan Run" (named for adjacent White Swan School), 3 miles southwest of Georgetown, Lewis Township, Brown County, Ohio (Higginsport, Ohio-Kentucky, quadrangle). Section 132 feet thick, including virtually complete Southgate and McMicken members. Divided into 121 sampled units.

DISTRIBUTION AND STRATIGRAPHIC SIGNIFICANCE OF EDEN CONODONTS

Thirty-six conodont species are now known (Table 1) from typical Eden strata in southwestern Ohio and adjacent Kentucky. Of these, only four named species are new; the ranges and geographic distribution of the remaining 32 species are well known from previous studies of Middle and Upper Ordovician conodont faunas, hence rather close comparison with presumably comparable faunas is possible.

Cordylodus delicatus, *C. flexuosus*, *Drepanodus homocurvatus*, *D. suberectus*, *Oistodus inclinatus*, *Ozarkodina robusta*, *Prioniodina oregonia*, and *Zygognathus deformis* are represented in all three members of the Eden and only a few samples failed to yield representatives of all these species. Conodonts like this have a long range and are well known from, or most closely related to, species common in Wilderness and Trenton rocks of the North American midcontinent province (Iowa, Minnesota, Missouri, Oklahoma, Texas). Furthermore, all these species are represented in Fairview and McMillan strata, and *Drepanodus suberectus*, *Oistodus inclinatus*, and *Prioniodina oregonia* range upward into the Richmond group. For these reasons, these species have little stratigraphic value; they are important,

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EXPLANATION OF PLATE 130

Figures drawn from photographs of specimens from the Eden formation.

FIG. *1*—*Drepanodus? altipes* Henningsmoen? Outer and inner lateral views, ×100. Fulton-Economy member, locality 13095. OSU 21423.

2—*Panderodus intermedius* (Branson & Mehl). Outer and inner lateral views, ×100. McMicken member, locality 13103. OSU 22165.

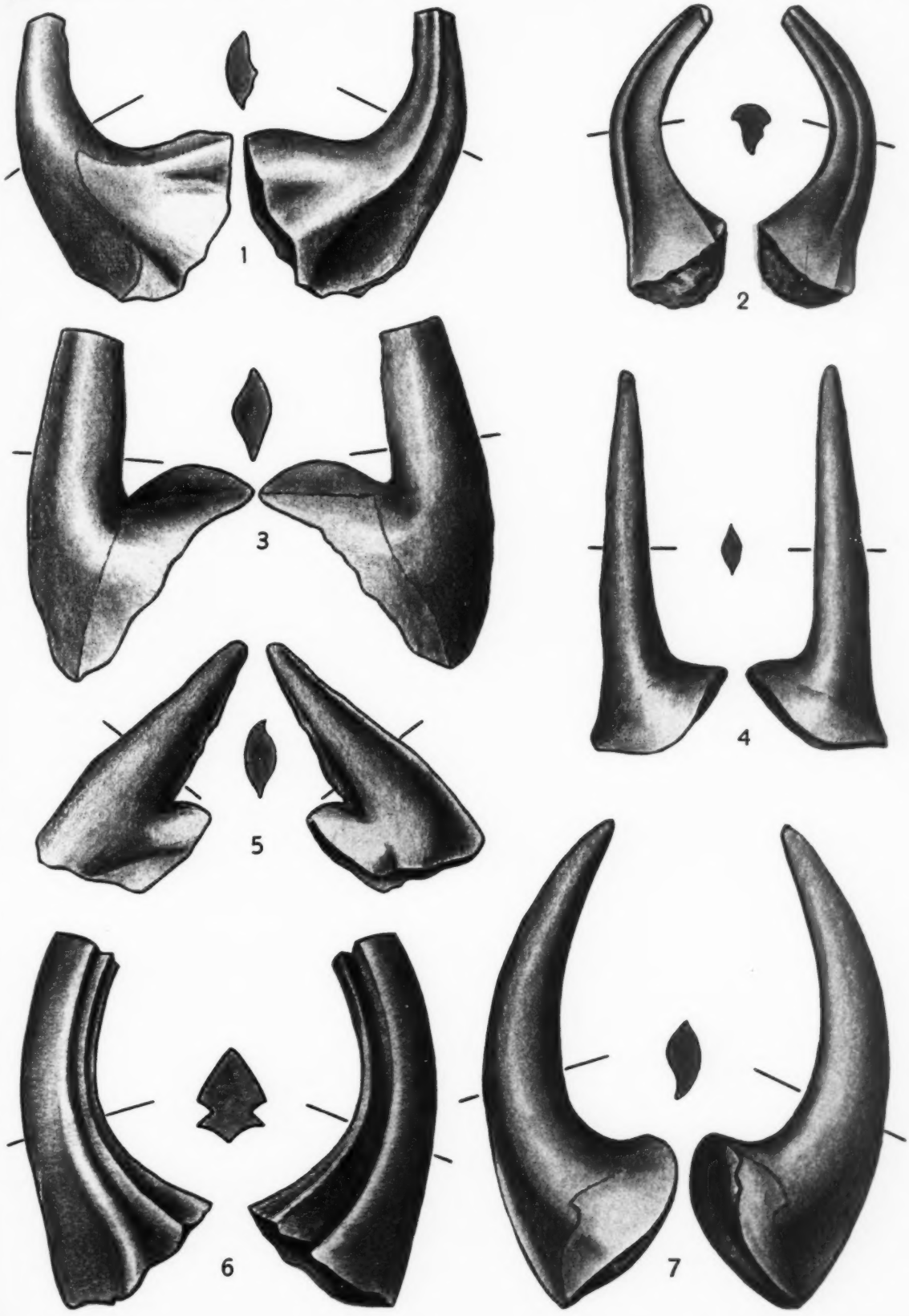
3—*Oistodus abundans* Branson & Mehl. Inner and outer lateral views, ×100. Southgate member, locality 13093. OSU 22136.

4—*Drepanodus suberectus* (Branson & Mehl). Two views, ×100. Southgate member, locality 13099. OSU 22141.

5—*Oistodus excelsus* Stauffer. Outer and inner lateral views, ×100. McMicken member, locality 13104. OSU 22171.

6—*Scolopodus insculptus* (Branson & Mehl). Lateral views, ×100. Fulton-Economy member, locality 13905. OSU 21420.

7—*Drepanodus homocurvatus* Lindström. Lateral views, ×50. McMicken member, locality 13104. OSU 22167.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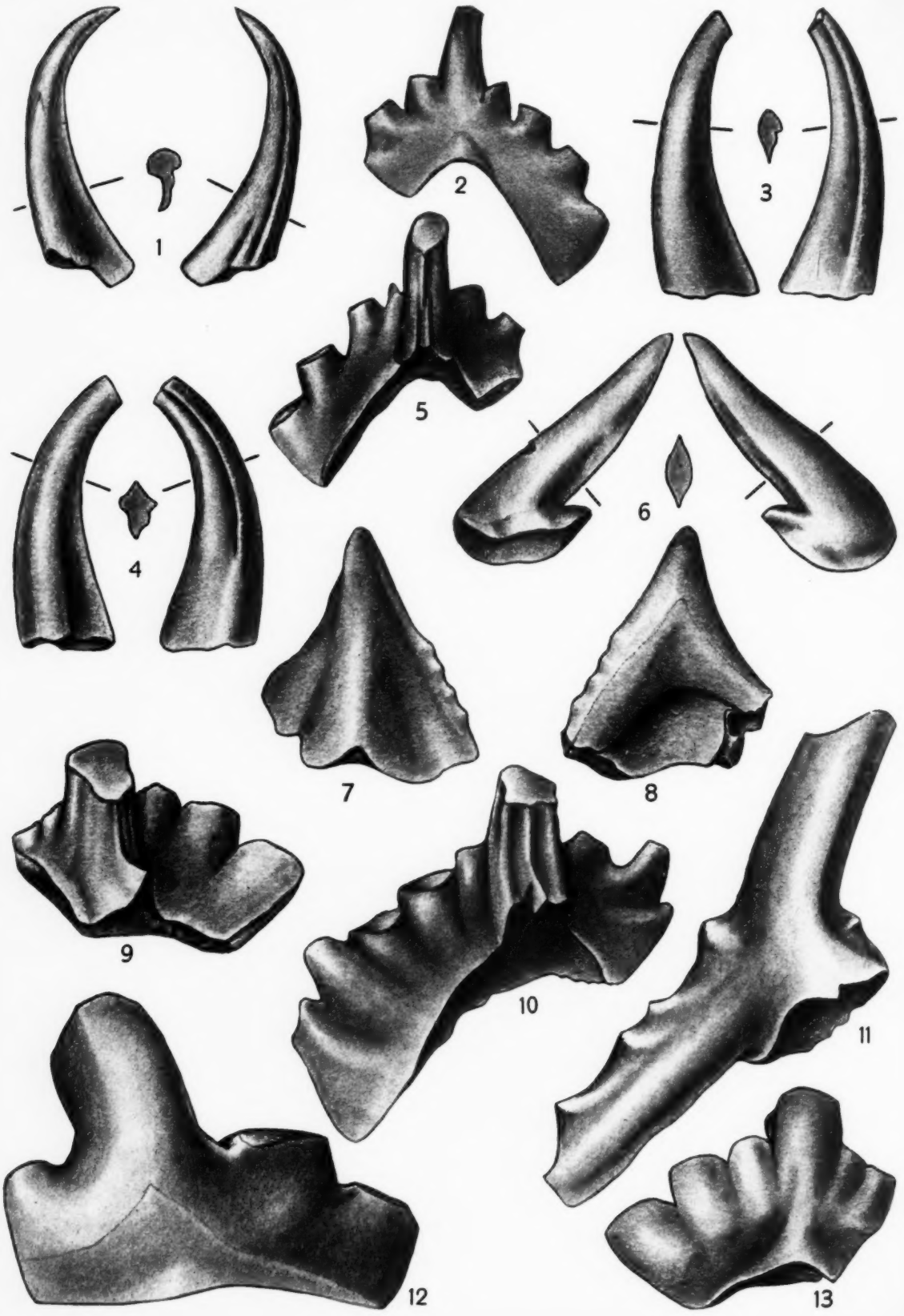
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TABLE 1—STRATIGRAPHIC DISTRIBUTION OF EDEN CONODONT SPECIES

Conodont species	Fulton-Economy member	Southgate member	McMicken member
Ambalodus elegans Rhodes	—		
Drepanodus? altipes Henningsmoen?	- - - - - -		
Keislognathus gracilis Rhodes	—		
Prioniodus, n. sp.	- - - - - -		
Scolopodus insculptus (B. & M.)	—		
Eoligonodina extensa (Rhodes)	—	—	
Panderodus striatus (Stauffer)	—	—	
Amorphognathus sp.	—	.....	—
Sagittodontus dentatus Ethington	—	.....	—
Panderodus unicostatus (B. & M.)		—	
Oistodus excelsus Stauffer		—	—
Oulodus mediocris B. & M.?		—	—
Panderodus gracilis (B. & M.)		—	—
Cordylodus excavatus, n. sp.			—
Panderodus intermedius (B. & M.)			—
Prioniodina delecta (Stauffer)			- - - - - -
Prioniodina rotunda, n. sp.			—
Trichonodella tenuis (B. & M.)			—
Ambalodus triangularis B. & M.	—	—	—
Belodina compressa (B. & M.)	—	—	—
Cordylodus delicatus B. & M.	—	—	—
Cordylodus flexuosus (B. & M.)	—	—	—
Dichognathus brevis B. & M.	—	—	—
D. extensa B. & M.	—	—	—
D. typica B. & M.	—	—	—
Drepanodus homocurvatus Lindström	—	—	—
D. suberectus (B. & M.)	—	—	—
Eobelodina fornicala (Stauffer)	—	—	—
Oistodus abundans B. & M.	—	—	—
O. inclinatus B. & M.	—	—	—
Ozarkodina robusta Stauffer	—	—	—
Phragmodus undatus B. & M.	—	—	—
Prioniodina oregonia B., M., & B.	—	—	—
Trichonodella angulata, n. sp.	—	—	—
T. subundulata, n. sp.	—	—	—
Zygognathus deformis (Stauffer)	—	—	—

EXPLANATION OF PLATE 131

Figures drawn from photographs of specimens from the Eden formation.

FIG. *1*—*Panderodus gracilis* (Branson & Mehl). Outer and inner lateral views, ×100. McMicken member, locality 13104. OSU 22176.

2,5—*Trichonodella subundulata*, n. sp. Anterior and posterior views of a cotype, ×100. Fulton-Economy member, locality 13097. OSU 21477.

3—*Panderodus unicostatus* (Branson & Mehl). Outer and inner lateral views, ×100. Southgate member, locality 13107. OSU 22148.

4—*Panderodus striatus* (Stauffer). Outer and inner lateral views, ×100. Fulton-Economy member, locality 13095. OSU 21421.

6—*Oistodus inclinatus* Branson & Mehl. Lateral views, ×50. McMicken member, locality 13106. OSU 22173.

7,8—*Sagittodontus dentatus* Ethington. Anterior and posterior views, ×100. McMicken member, locality 13104. OSU 22194.

9,13—*Trichonodella angulata*, n. sp. Posterior and anterior views of the holotype, ×100. McMicken member, locality 13108. OSU 22198.

10—*Trichonodella subundulata*, n. sp. Posterior view of a cotype, ×100. Southgate member, locality 13107. OSU 22155.

11—*Prioniodina delecta* (Stauffer). Inner lateral view of an incomplete specimen, ×100. McMicken member, locality 13107. OSU 22229.

12—*Prioniodina rotunda*, n. sp. Outer lateral view of a cotype, ×100. McMicken member, locality 13104. OSU 22233.

however, in that they are apparently provincial indices. All eight species are abundant in Eden rocks, but a study of our collections indicates that they become increasingly more numerous from the bottom to the top of any Eden section. Representatives of these eight species, taken together, constitute 15% of our Fulton-Economy collections and about 42% of collections from the Southgate and McMicken members. The higher percentages are probably maintained through most of the Fairview and McMillan formations.

Forty to 50% of the conodont-elements collected from each Eden member is referable to *Phragmodus undatus* and *Oistodus abundans*. *Phragmodus* is a characteristic genus in Middle and early Upper Ordovician rocks in the North American midcontinent and valid species of the genus have not been reported from rocks deposited elsewhere. *P. undatus*, which may be a species-group, is widespread in the North American midcontinent; it has been reported from the Plattin, Kimmswick, and Orchard Creek ("Maquoketa") formations of Missouri, the Galena and Maquoketa formations of Iowa and Minnesota, the Ft. Peña, Woods Hollow, and Maravillas formations of Texas, and the Viola formation of Oklahoma. *Oistodus abundans* is not of quite such widespread occurrence, but it, too, has been reported from most of the formations just listed. Both species range, with decreasing abundance, through the Fairview and McMillan formations of Ohio and adjacent states, but they are not known from formations in the Richmond group. These facts again suggest that these two species are long-ranging (Ashby?-Maysville) province indicators and we attach little stratigraphic significance to their abundance in the Eden.

Belodina compressa (?=*B. grandis*) and *Eobelodina fornicala* are also known to be characteristic of Wilderness, Trenton, and early Upper Ordovician rocks in the North American midcontinent. Neither of these species is particularly common in the typical Eden, but they are distinctive forms not easily confused with other conodont-elements. Neither species appears to range above the Eden so, at least provisionally, their presence in Ordovician conodont faunas may be interpreted to mean an age in the Wilderness through Eden interval.

Dichognathus brevis, *D. extensa*, and *D. typica* account for about 22% of the conodont-elements in our collections from the Fulton-Economy and Southgate members, but for only about 6% of our McMicken conodonts. The lower percentage figure, or a somewhat intermediate one, seems to be maintained through the superjacent Fairview and McMillan. *Dichognathus* is not known from the Richmond group. These somewhat gradational species are common in Middle and early Upper Ordovician conodont faunas in the North American midcontinent and have been reported from Europe only in association with other elements that suggest migration from the midcontinent province. Consequently, even though these forms are distinctive, they are of little stratigraphic significance.

Oistodus, *Oulodus*, and *Panderodus* contain many long-ranging species, several of which are represented by a few Eden individuals that are strikingly similar to forms reported from Middle and early Upper Ordovician strata elsewhere in the North American midcontinent province. The presence of *Oistodus excelsus*, *Oulodus mediocris*, and *Panderodus gracilis* in the Southgate and McMicken, and the absence of such forms in our extensive Fulton-Economy collections, may be of considerable significance, however. Although these forms are indices only to province, their presence in middle and upper Eden, Fairview, and McMillan strata seems to suggest the return to the Cincinnati region of more typical midcontinent forms in middle and late Eden, and Maysville time. This inference is strengthened by the fact that previously mentioned midcontinent species increase in abundance in Southgate and McMicken, and Fairview and McMillan strata.

Two new species, *Cordylodus excavatus* and *Prioniodina rotunda*, appear for the first time in the McMicken member and become abundant in the overlying Fairview. These are both large and distinctive species and their recognition in other Cincinnatian faunas should aid in correlation. At present, however, we accord them no particular significance.

Ambalodus elegans, *A. triangularis*, *Drepanodus? altipes*, *Eoligonodina elongata*, *Keis-*

lognathus gracilis, *Prioniodus*, *Sagittodontus dentatus*, and *Scolopodus insculptus* are not common genera or species in Ordovician rocks of the North American midcontinent; rather, they seem more characteristic of Anglo-Scandinavian and Appalachian conodont faunas. All these species occur in the Fulton-Economy and serve to distinguish it from the Southgate and McMicken, from which only *Eoligonodina* and *Sagittodontus* are known.

Ambalodus, represented by some six species, has a long range (Tremadoc into the lowermost Ashgill) in the Ordovician of the Anglo-Scandinavian and Appalachian provinces, hence the genus may be considered typical of Anglo-Scandinavian and Appalachian conodont faunas in general. *A. elegans*, known previously only from the upper Caradocian Pen-y-garnedd and Gelligrin limestones of Wales and probably from shales in the earlier Caradocian zone of *Climacograptus wilsoni* in southwestern Scotland, occurs also in the Fulton-Economy member of the Eden. *A. triangularis* is based on types from the Thebes sandstone member of the Orchard Creek formation of Missouri, but has been reported from the Maravillas formation in Texas, from a "Maquoketa" shale horizon in the Kansas subsurface, from the Gelli-grin and Pen-y-garnedd limestones of Wales, from the Keisley limestone near Keisley, Westmorland, England, from the Stewartville and Dubuque members of the Galena formation, and from the Phosphatic (Depauperate) member of the Maquoketa shale in Iowa. In Ohio, *A. triangularis* ranges through the Eden and the Fairview formation, but is not known from the McMillan formation or the Richmond group.

The type of *Drepanodus? altipes* is from the so-called Black Tretaspis Shale in a well core at Kullatorp, Kinnekulle, Sweden. Graptolites found in the Black Tretaspis Shale indicate (Henningsmoen, 1948) that it belongs in the zone of *Pleurograptus linearis* and *Climacograptus styloideus*, hence it is at least broadly equivalent to the Gelligrin and Pen-y-garnedd limestones of Wales, from which *D.? altipes* is also known. However, the Black Tretaspis Shale is probably somewhat older than the Keisley limestone of Westmorland, England, which also contains common *D.? altipes*, but is generally considered (Rhodes, 1955) to be basal Ashgillian, rather than uppermost Caradocian, in age.

Eoligonodina elongata has heretofore been reported only from the Gelli-grin and Pen-y-garnedd limestones of Wales and the Dubuque member of the Galena formation of Iowa, although closely related forms occur in the Prosser member of the Galena and the Keisley limestone of Westmorland, England. The type species of *Eoligonodina* is from the Richmond group of the Cincinnati region.

As its name suggests, *Keislognathus* was originally described from the Keisley limestone of England, but representatives of this distinctive genus are now known from the Stewartville and Dubuque members of the Galena formation in Iowa and from the Fulton-Economy member of the Eden in Ohio. In addition, the genus "reappears" briefly in the basal Fairview of Ohio. *Keislognathus* is closely related to and difficult to distinguish from *Holodontus*, a genus heretofore reported only from the Gelli-grin and Pen-y-garnedd formations of Wales.

Prioniodus, as restricted by Öpik (1936) and Lindström (1954), is based on Lower Ordovician types from Estonia and seems also to be characteristic of Anglo-Scandinavian conodont faunas. In Europe, valid representatives of *Prioniodus* have been reported from rocks as young as strata in the zone of *Climacograptus wilsoni* (Lindström, 1957); we are not aware of any previously described North American species that belong in the genus, but we suspect that Stauffer's (1935a, 1935b) *Dichognathus variabilis* may be a *Prionidus*- (or *Eoligonodina*) rather than a *Dichognathus*.

Sagittodontus dentatus is based on specimens from the Dubuque member of the Galena formation in Iowa and representatives of it occur in both the Fulton-Economy and McMicken members of the typical Eden. *S. dentatus* is indeed similar to *S. robustus*, the type species, known only from the Gelli-grin and Pen-y-garnedd-limestones of Wales, but differs somewhat from *S. gracilis*, reported from the early Middle Ordovician (Llanvirn-Llandeilo) Randschiefer series of Bavaria.

Scolopodus insculptus is known from both

Europe and North America in rocks included in or corresponding to the upper Caradocian zone of *Pleurograptus linearis* or the superjacent lower Ashgill. In Europe, the species is known from the Gelli-grin, Pen-y-garnedd, and Keisley limestones of Great Britain; in North America, the form has been collected from the Fulton-Economy member of the type Eden, from the Maravillas formation of Texas, from the Thebes sandstone member of the Orchard Creek formation of Missouri, and from the Dubuque member of the Galena formation in Iowa. In addition, we have a large number of undescribed conodont-elements strikingly reminiscent of this species in collections from the Pratt Ferry formation (early Porterfield) of Alabama.

The above remarks rather strongly indicate that *Ambalodus*, *Keislognathus*, *Sagittodontus*, probably *Prioniodus* and *Scolopodus*, and perhaps even *Eoligonodina*, all of which are represented in the Fulton-Economy member of the Eden, but are rare or absent in superjacent members, are genera more characteristic of the Anglo-Scandinavian-Appalachian province than of the North American midcontinent province. The fact that this combination of forms appears in a rather limited interval in the Ordovician of the North American midcontinent suggests that there was an invasion of Anglo-Scandinavian-Appalachian forms into the midcontinent in early Eden time and a consequent dilution of or emigration of the more abundant midcontinent species. The invasion must have been of short duration, however, for the increasing abundance of characteristic micontinent species in middle and upper Eden time and a contemporaneous dwindling, in the Cincinnati region, of the distinctive Anglo-Scandinavian-Appalachian forms indicates a return to faunal conditions much like those of the late Middle Ordovician. Spjeldnaes (1958) has suggested that such zoogeographic fluctuations may have been caused by climatic variations in the Ordovician. If this were the case, it would mean that there was in early Eden time, a northwestward shift of the presumably cold-temperate Anglo-Scandinavian-Appalachian faunas into the probably warm-temperate midcontinent province, followed, in the later Eden and Maysville by a return of these colder water forms to the Anglo-Scandinavian-Appalachian region, a re-establishment of the warm-temperate fauna in the Cincinnati region, and, in the Richmond, an invasion of even warmer tropical or subtropical forms into the midcontinent, probably from the northwest or north. Such a pattern might, in addition, explain the lack of corals in Eden, Fairview, and McMillan rocks, as well as the dearth of any variety of cephalopods in most of the same strata.

Regardless of the reason for the apparent migration of Anglo-Scandinavian and Appalachian conodonts into the North American midcontinent, assemblages and sequences of conodont-elements were produced that are distinctive, of rather limited vertical distribution, and of widespread geographic occurrence. The mixed Anglo-Scandinavian - midcontinent assemblage found in the lower and early middle Eden, appears also to characterize the Stewartville and Dubuque members of the Galena and the Phosphatic member of the Maquoketa formations of Iowa, which we consider equivalent to at least the early part of the Eden of Ohio.

The Elgin, Clermont, and Ft. Atkinson members of the Maquoketa formation in Iowa, which succeed the Stewartville and Dubuque stratigraphically, lack the distinctive Anglo-Scandinavian elements of the subjacent Stewartville and Dubuque, but they contain *Phragmodus undatus*, *Dichognathus*, and *Belodina* (in addition to other things) which suggests to us that these units are late Edenian and lower Maysvillian in age. The lower shaly part of the Brainerd member lacks *Belodina*, but contains *Phragmodus undatus* and *Dichognathus*, indicating that it may be of upper Maysville (McMillan) age. The Brainerd limestone, on the other hand, seems to contain a "flood" of *Panderodus*, as does the type Richmond—but it also contains a few *Phragmodus*, which may indicate that it is no younger than the Arnheim (early Richmond), in which *Phragmodus* seems to make its last appearance.

The shale member of the Orchard Creek ("Maquoketa") formation of Missouri has yielded only a few conodont species, none of which is distinctive enough to suggest positive correlation. However, the presence of

Trichonodella tenuis in the lower Orchard Creek and in the McMicken member of the Eden may indicate that the two are of about the same age. The Thebes sandstone member of the Orchard Creek yielded most of Branson & Mehl's "Maquoketa" conodonts. This unit contains *Amorophognathus* and *Ambalodus triangularis*, as well as *Scolopodus insculptus*, *S.? dissimilaris*, and *Phragmodus simplex*, a species much like a *Phragmodus* that appears in the Fairview formation (early Maysville) of Ohio. Since neither *Amorphognathus* nor *Ambalodus triangularis* appears to range beyond the Fairview formation, it seems probable that the Thebes sandstone is either very late Edenian or early Maysvillian in age. Similarly, *Amorphognathus* and *Ambalodus* range throughout the Maravillas formation of Texas, which suggests that it is also of late Edenian or early Maysvillian age, or both.

SYSTEMATIC DESCRIPTIONS

Genus AMBALODUS Branson & Mehl, 1933
Type species: *Ambalodus triangularis* Branson & Mehl, 1933

Paired, individually asymmetrical, platform-like conodont-elements, which are more or less triangular or crescent-shaped in plan. The under surface is excavated; the upper surface is smooth or somewhat concave, and varies in width in different species. The convex margin of the base is produced upward into a similarly convex, blade-like row of inclined, sharp-pointed, basally fused denticles. A spike-like denticle of superior size occurs at the point of maximum convexity of the base. The concave margin of the platform-like base is marked, at least in some species, by a non-denticulate flange that parallels the denticulate, blade-like series of the convex margin. On the convex margin of the base, from a point near, or slightly anterior to the base of the apical denticle, there is produced an excavated process, of limited development in some species, but of considerable length and complexity in others. The upper surface of this lateral process bears one or two keel-like ridges, one of which may bear discrete denticles.

As in other conodont-elements, the excavated side of the platform-like base is considered the *under* side, and, for descriptive purposes, is oriented horizontally. The convex margin of the base is considered to be its *outer* side; the concave side, its *inner* side. The direction toward which the denticles of the blade-like series are inclined is considered to be *posterior*. The lateral process occurs on the convex side of the base, hence is referred to as an *outer lateral process*.

Remarks.—Four species of *Ambalodus* have been named. Representatives of the type species, *A. triangularis* Branson & Mehl, are known from the Thebes sandstone member of the Orchard Creek formation at Ozora, Missouri (Branson & Mehl, 1933), from the Maravillas formation in the vicinity of Marathon, Texas (Graves & Ellison, 1941), from a "Maquoketa shale" horizon in the subsurface of Stafford County, Kansas. from the Gelli-grin and Pen-y-garnedd limestones of Wales (Rhodes, 1953), from the Keisley limestone near Keisley, Westmorland, England (Rhodes, 1955), from the Stewartville and Dubuque members of the Galena formation in northeastern Iowa (Ethington, 1959), and from the Phosphatic (Depauperate) member of the typical Maquoketa shale of Iowa (Glenister, 1957).

Three additional species, *Ambalodus elegans*, *A. pulcher*, and *A. robustus*, were described by Rhodes (1953) from the Pen-y-garnedd and Gelli-grin limestones of Wales and an indeterminate form was found in collections from the Llandeilo limestone of Wales. Lindström (1957) compares a distorted *Ambalodus* from graptolitic shales in the *Climacograptus wilsoni* zone at Morroch Bay, southwestern Scotland, with *A. elegans* Rhodes, and in an earlier publication (1954) described, as *Ambalodus*, n. sp., a single specimen from strata of the *Ceratopyge forficula* zone (Tremadoc) in the Anga Quarry, Stora Backor, Västergötland, Sweden. In addition, it should be noted that new species of *Ambalodus* are represented by a great number of specimens in an undescribed fauna from the early Porterfield Pratt Ferry formation of Alabama, which also contains many conodont species now thought to be typical of the Ordovician in the Anglo-Scandinavian and Appalachian faunal provinces.

Although the evidence is not yet conclusive, it appears that *Ambalodus* is a long-ranging genus in the Anglo-Scandinavian

and Appalachian faunal provinces. However, all the rocks of the North American midcontinent from which it has been reported seem to be of early Upper Ordovician age (Eden and early Maysville), which suggests that in early Upper Ordovician time there was a migration of forms typical of the Anglo-Scandinavian and Appalachian provinces into the midcontinent of North America. Consequently, even though *Ambalodus* itself is long-ranging, the migration that *A. triangularis* seems to represent is of considerable importance in the demonstration of contemporaneity among rocks of the North American midcontinent.

Ambalodus triangularis occurs throughout the Eden formation and ranges through the superjacent Fairview formation. *A. elegans* Rhodes is known in Ohio only from the Fulton-Economy member of the Eden.

Ambalodus elegans Rhodes
Pl. 132, fig. 9

Ambalodus elegans Rhodes, 1953, Phil. Trans. Roy. Soc. London, ser. B, no. 697, p. 278–279, pl. 20, figs. 21–25.

Six specimens similar to the figured types of *Ambalodus elegans* Rhodes occur in our collections from the lower part of the Economy member of the Eden formation, in a horizon that may well represent the upper part of the Fulton beds. These specimens are here referred without question to Rhodes' species. All these specimens are alike in that the base is laterally compressed, prominently arched, and only slightly crescentic in plan view. In addition, the most nearly complete specimens possess a well developed, bicarinate outer lateral process that is directed downward and backward. The anterior ridge on the outer lateral process is distinctly denticulated. The process is developed from the outer lateral face of the denticle immediately anterior to the apical denticle.

Remarks.—*Ambalodus elegans* differs from other species of *Ambalodus* in that its base is narrow, the unit is only slightly convex in plan view, and the prominent outer lateral process has a bicarinate upper surface. These conodonts are distinctly different from *A. triangularis*, the type of *Ambalodus*, for in that species the platform-like base is broad, its anterior and posterior elements join at nearly right angles, and the outer lateral process is only weakly developed.

Occurrence.—Fulton-Economy member, Eden formation, 12′ 9″ above base, locality 13096.

Types.—Figured hypotype, OSU 21482; unfigured hypotypes, OSU 22131.

Ambalodus triangularis Branson & Mehl
Pl. 133, fig. 4

Ambalodus triangularis Branson & Mehl, 1933, Missouri Univ. Studies, v. 8, p. 127,128, pl. 10, figs. 35–37; Graves & Ellison, 1941, Missouri School Mines & Metallurgy Bull., Tech. Ser., v. 14, p. 5,7, pl. 3, figs. 29, 33–35; Imbt, 1941, *in* Stratigraphic type oil fields, p. 148; Branson & Mehl, 1944, *in* Index fossils N. America, p. 237, pl. 93, figs. 7,8; Branson, 1944, Missouri Univ. Studies, v. 19, p. 95; Fay, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art 3, p. 26; Rhodes, 1953, Phil. Trans. Roy. Soc. London, ser. 3, no. 647, p. 280, pl. 20, figs. 28–31; Rhodes, 1955, Quart. Jour. Geol. Soc. London, v. 111, p. 122,123, pl. 7, figs. 9–14; Glenister, 1957, Jour. Paleontology, v. 31, p. 722, pl. 88, figs. 20,21; Ethington, 1959, Jour. Paleontology, v. 33, p. 269, pl. 40, fig. 12.

Remarks.—This distinctive species is represented by a considerable number of individuals in our collections from all levels of the Eden formation. Our specimens are perhaps somewhat more massive than the figured type and the anterior process is not as markedly down-arched as is that of the holotype. However, in general, the comparison is very close. This species can be distinguished from *Ambalodus elegans* by the fact that the outer lateral process is only weakly developed and bears on its upper surface just a single ridge. Furthermore, *A. triangularis* is more strongly bowed than *A. elegans* and the platform-like extension of the inner margin of the blade-base is wider and more massive.

Occurrence.—Fulton-Economy, Southgate, and McMicken members, localities 13093, 13095, 13099, 13100, 13104–13108.

Types.—Figured hypotype, OSU 21483; unfigured hypotypes, OSU 21484, 22121, 22122, 22161, 22162.

Genus Amorphognathus Branson & Mehl, 1933

Amorphognathus sp.
Pl. 133, figs. 1,2

We have a number of fragmentary specimens from the Eden that belong in *Amorphognathus*, but they are so incomplete that

we cannot identify them specifically. All these specimens are similar in that they represent lanceolate, ray-like platform elements, characterized by an under surface that is broadly concave transversely and an upper surface that is flat to slightly concave and marked longtitudinally by a prominent, somewhat sinuous crest composed of laterally compressed denticles that are fused proximally, but discrete and sharp-pointed distally. The upper and under surfaces are separated by narrow lateral faces that are longitudinally concave and appear to form a distinct groove around the periphery of the fragments.

Remarks.—Most forms previously referred to *Amorphognathus* seem to have excavated under surfaces. It should be noted, however, that the several forms placed in *Polyplacognathus* by Stauffer (1935b) have ridged, or longitudinally carinate under surfaces. These species have, for several years, been included in *Amorphognathus* (Branson, 1944; Ellison, 1946; Sweet, 1955, Glenister, 1957), but it is possible that the marked difference in the attachment surfaces should be regarded as a character of generic importance. Glenister (1957) mentions the existence of a "basal plate," interpreted to be broken from most specimens and lost. Presumably, this basal plate is continuous with the flanges of the lateral margins. We have seen no such structure in the specimens we are studying and its relationships are not entirely clear from Glenister's description of it. It may compare, however, to the basal "funnel" (trichter) described by Gross (1957) from other conodonts and noted in as yet undescribed species of *Amorphognathus* in collections from the Pratt Ferry formation of Alabama.

Occurrence.—Fulton-Economy member, locality 13094; McMicken member, localities 13100, 13104, 13105, 13107. *Amorphognathus* is not known from the Southgate member of the Eden and representatives of the genus are not common in either the Fulton-Economy or McMicken. Large collections from the superjacent Fairview formation indicate that the genus extends at least through the Mt. Hope member of that formation.

Types.—Figured hypotypes, OSU 21486; unfigured hypotypes, OSU 21485, 22164.

Genus BELODINA Ethington, 1959

Type species: *Belodus grandis* Stauffer, 1955

This taxon was established recently by Ethington for the complex conodont-elements long referred by American writers to *Belodus* Pander. These elements consist of rather massive, laterally asymmetrical, proclined cusps, the concave edges of which bear a series of prominent, confluent, laterally compressed denticles that often appear to penetrate into the cusp itself. The sides of the element may bear one or more longitudinal carinae and are generally marked by a series of fine striations parallel to the concave margin of the cusp. The posterior margin of the element is penetrated by two conical cavities, the lower of which is slender, somewhat sinuous, distally thread-like, and penetrates deeply into the cusp. The upper of the two cavities is compressed and projects anteriorly only as far as the posterior end of the denticulate margin of the cusp.

Remarks.—As Ethington (1959) points out, a considerable number of conodont-elements, primarily from the Ordovician of North America, but also from the Devonian of both North America and England, have been referred without question to *Belodus* Pander, even though many of these exhibit features not specifically mentioned by Pander. Presumably, the genus has been interpreted formally and we can find no mention in the literature of its internal structure—nor any indication that this has figured at all in previous determinations. Unfortunately, most of the specimens in our collections have been altered to a greater or lesser degree by *post mortem* solution so that we have not been able to unravel their many structural peculiarities in a truly satisfactory manner. However, we have prepared several thin-sections of these perplexing units and a study of these is sufficient to indicate that they differ rather considerably from all other types of conodonts with which we are familiar. That is, the elements appear not to have been built-up by the accretion of successive cone-shaped lamellae, but by the addition, at least in later growth stages, of curving, semi-concentric laminae, more or less parallel to the axis of the cusp. These laminae appear to have been incomplete along their upper edges and these

edges are probably responsible for longitudinal striations prominent on both cusp faces.

Insofar as we are aware, *Belodina* is known only from the Middle and early Upper Ordovician (Eden and Maysville) of the North American midcontinent province. In this province, the oldest undoubted record of *Belodina* is in the Glenwood shale (Wilderness) of Minnesota (Stauffer, 1935a), and representatives of the genus are not uncommon components of known later Middle Ordovician conodont faunas. We have a number of representatives of *Belodina* in our collections from the typical Eden of Ohio and similar forms occur in the Stewartville, Dubuque, and Maquoketa of Iowa, which we interpret to be Edenian and Maysvillian in age. *Belodina* has not yet been reported from known Richmondian strata. Devonian species of *Belodus*, reported by Stauffer (1940) and Rhodes & Dineley (1957) do not belong in *Belodina* and it is doubtful if they belong in *Belodus*.

BELODINA COMPRESSA (Branson & Mehl)
Pl. 133, figs. 12,15

Belodus compressus BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 114, pl. 9, figs. 15–16; FURNISH, BARRAGY, & MILLER, 1936, Am. Assoc. Petroleum Geologists, v. 20, p. 1334, pl. 1, fig. 10; pl. 2, fig. 13; BRANSON & MEHL, 1944, *in* Index fossils N. America, p. 79–80, pl. 11, figs. 36–37; BRANSON, 1944, Missouri Univ. Studies, v. 19, p. 81,89, pl. 12, figs. 9–10; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 67.

Entire element compressed; consisting of massive, recurved cusp with denticulated concave margin continuous proximally with flange-like process. Convex margin of cusp sharp, cusp faces longitudinally striated, striae intersecting convex margin of cusp at acute angles. Inner side of cusp marked about a third of its width above the convex margin by an inconspicuous longitudinal

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EXPLANATION OF PLATE 132

Figures drawn from photographs of specimens from the Eden formation.

FIG. *1,5—Zygognathus deformis* (Stauffer). Outer and inner lateral views of two specimens, ×100. *1*, A dextral specimen from the Southgate member, locality 13093; and *2*, a sinistral specimen from the McMicken member, locality 13108. OSU 22157, 22217.

2,3—Dichognathus extensa Branson & Mehl. Outer and inner lateral views of two specimens, ×100. Fulton-Economy member, locality 13097. OSU 21439, 21438.

4—Eoligonodina elongata (Rhodes). Inner lateral view, ×100. Fulton-Economy member, locality 13097. OSU 21475.

6—Dichognathus typica Branson & Mehl. Outer lateral view, ×100. Fulton-Economy member, locality 13097. OSU 21436.

7—Dichognathus brevis Branson & Mehl. Outer lateral view, ×100. Fulton-Economy member, locality 13093. OSU 21440.

8—Prioniodus, n. sp. Inner lateral view, ×100. Fulton-Economy member, locality 13100. OSU 21470.

9—Ambalodus elegans Rhodes. Superior view, ×100. Fulton-Economy member, locality 13098. OSU 21482.

10,15—Trichonodella tenuis (Branson & Mehl). Anterior and posterior views, ×100. McMicken member, locality 13107. OSU 22204.

11—Keislognathus gracilis Rhodes. Inner lateral view, ×100. Fulton-Economy member, locality 13095. OSU 21478.

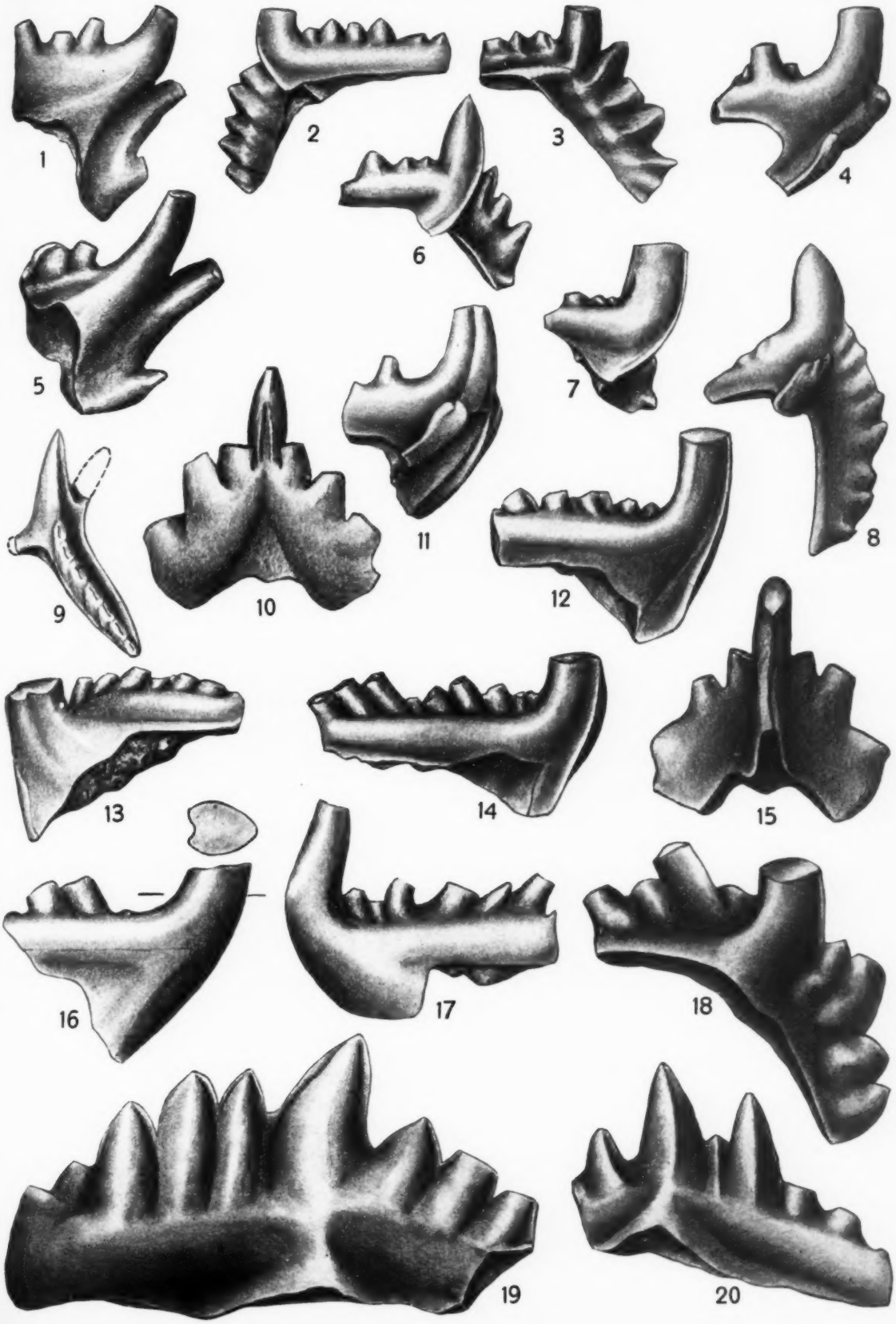
12,14,17—Cordylodus delicatus Branson & Mehl. *12,14*, Inner lateral and *17*, outer lateral views of three specimens, ×100, McMicken member, localities 13104, 13107. OSU 22182, 22180, 22185.

FIG. *13—Cordylodus flexuosus* (Branson & Mehl). Inner lateral view, ×100. McMicken member, locality 13105. OSU 22186.

16—Cordylodus excavatus, n. sp. Lateral view of the holotype, ×100. McMicken member, locality 13105. OSU 22183.

18—Prioniodina oregonia Branson, Mehl, & Branson. Inner lateral view, ×100. Fulton-Economy member, locality 13099. OSU 21480.

19,20—Ozarkodina robusta Stauffer. Outer and inner lateral views, ×100, of two specimens; *19*, from Southgate member, locality 13093; *20* from McMicken member, locality 13105. OSU 22225.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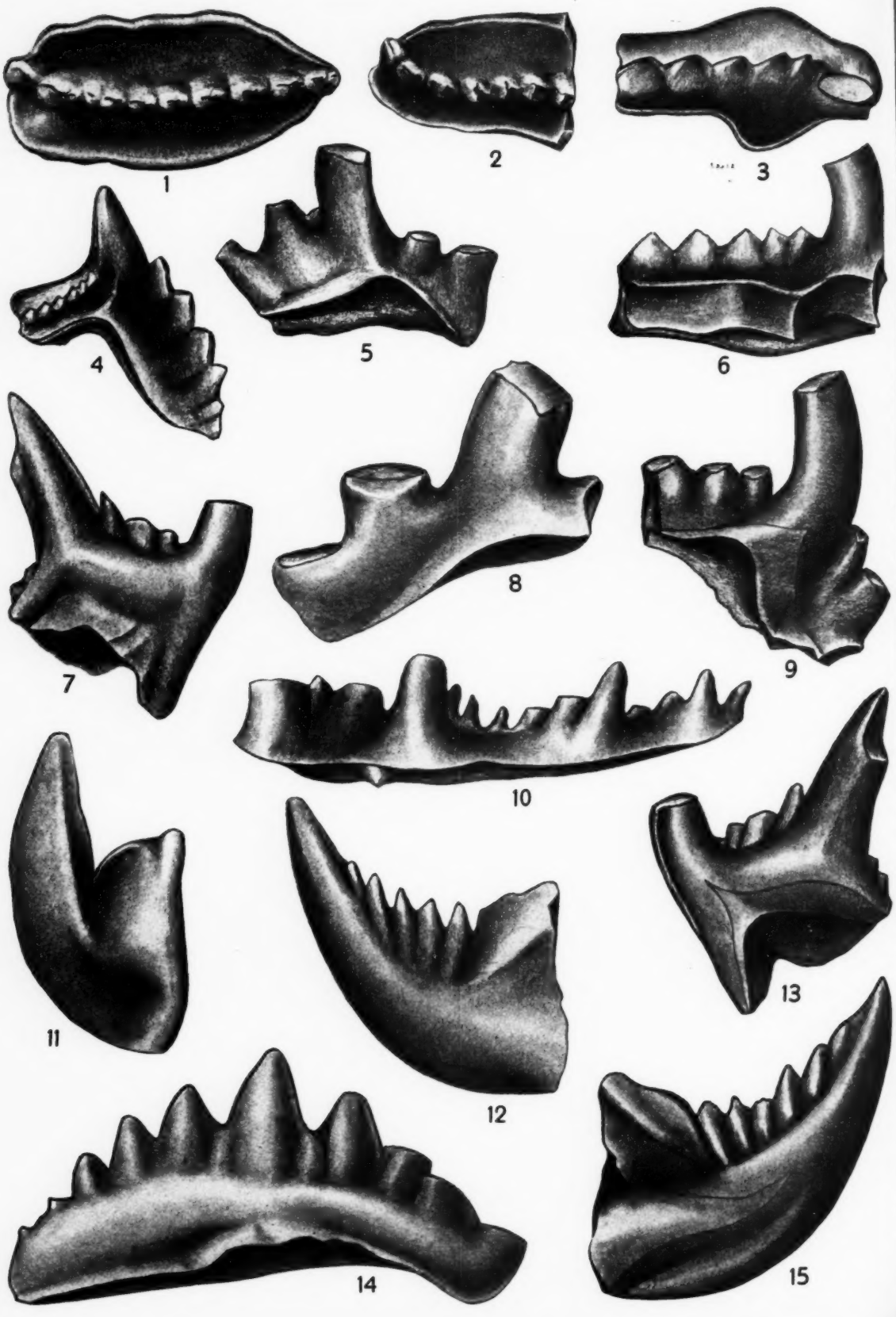
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groove and constricted along a line marking the apparent inner edge of the denticle series. This latter constriction continues in a smooth curve to the basal margin of the unit. Outer face flat or only slightly convex, but separated from flange-like process on concave cusp margin by a slight constriction extending apicad from the basal margin. Concave margin of cusp produced into 5 or 6 apically discrete, compressed denticles that appear to be sheathed (and in advanced forms to be completely overgrown) by extensions of the laminae that sheathe the cusp.

Cusp deeply excavated by two laterally compressed, subconical cavities. The lower of these extends to approximately cusp midlength and is prolonged for an indefinite distance as a thread-like tube. Near its posterior end, the major cavity becomes confluent with a somewhat shorter upper cavity that is also compressed and extends apicad beneath the flange-like process of the denticulate margin to the posterior end of the denticle series. A regular series of fine lines perpendicular to the axis of the flange-like process suggests that the upper cavity (and perhaps the lower one) was prolonged posteriorly by progressive extension of the cusp laminae.

Remarks.—Eden specimens are closely similar in comparable features to the representatives of *Belodina compressa* described from the Plattin and Kimmswick limestones of Missouri, hence we are referring them to that species without question. They are also similar, however, to the several described representatives of *Belodina grandis* (Stauffer) from the Decorah, Prosser, Stewartville, and Dubuque of the Upper Mississippi Valley (Stauffer, 1935b; Ethington, 1959) and we see no way in which these two species can be objectively distinguished. Consequently, we suspect that Stauffer's *B. grandis* should be regarded as a junior subjective synonym of Branson & Mehl's *B. compressa* and that the type of *Belodina* should be *B. compressa* (Branson & Mehl) rather than *B. grandis* (Stauffer). We hesitate to make this revision, however, for we have not studied the type specimens of either species. Both species are of about the same age (Branson & Mehl's Plattin conodonts almost certainly came from the Zell or uppermost member of the Plattin).

Occurrence.—Representatives of this large

EXPLANATION OF PLATE 133

Figures drawn from photographs of specimens from the Eden formation.

FIG. *1,2*—*Amorphognathus* sp. Superior views, ×100, of two specimens. Fulton-Economy member, locality 13094; McMicken member, locality 13100. OSU 21486, 22163.

3,6—*Genus and species undet.* Superior and inner lateral views, ×100, of the expanded platform-like part of a specimen from the Fulton-Economy member, locality 13095. OSU 21488. May represent an undescribed genus.

4—*Ambalodus triangularis* Branson & Mehl. Inner lateral view, ×100. Fulton-Economy member, locality 13095. OSU 21483.

5—*Oulodus mediocris* Branson & Mehl? Posterior view, X100. McMicken member, locality 13108. OSU 22223.

7,10,13—*Phragmodus undatus* Branson & Mehl. *7,13,* Outer and inner lateral views of a large specimen, ×100. Fulton-Economy member, locality 13095; *10,* lateral view of a fragmentary posterior bar, ×100. McMicken member, locality 13107. OSU 21448, 22192.

8—*Prioniodina rotunda,* n. sp. Inner lateral view of a cotype, ×100. McMicken member, locality 13105. OSU 22232.

9—*Prioniodina oregonia* Branson, Mehl, & Branson. Inner lateral view, ×100. Fulton-Economy member, locality 13099. OSU 21481.

11—*Eobelodina fornicala* (Stauffer). Inner lateral view, ×100. Southgate member, locality 13099. OSU 22139.

12,15—*Belodina compressa* (Branson & Mehl). Outer lateral and inner lateral views, ×100, of two specimens. Fulton-Economy and Southgate members, localities 13094, 13100. OSU 21434, 22123.

14—*Ozarkodina robusta* Stauffer. Inner lateral view, ×100. Fulton-Economy member, locality 13095. OSU 21453.

and distinctive species have been collected from units throughout the Eden. It is known from the Fulton-Economy, Southgate, and McMicken at localities 13093, 13095, 13097, 13099, 13100, 13104–13106, 13108.

Genus CORDYLODUS Pander, 1856
Type species: *Cordylodus angulatus* Pander, 1856

Based on *Cordylodus angulatus*, the genus *Cordylodus* seems to include only compound conodont-elements with denticulated posterior processes, undenticulated anterior costae (more or less distinctly developed) and no lateral ribs, ridges, costae, or processes. A large number of conodonts come within the confines of such a diagnosis and there seems to be little doubt but that those previously described under the names of *Barbarodina* Stauffer, *Plectodina* Stauffer, *Subcordylodus* Stauffer, and *Cyrtoniodus* Stauffer should now be referred to *Cordylodus*. In addition, the species *Prioniodus? flexuosus* Branson & Mehl is apparently a *Cordylodus* and we see no way in which it can be distinguished from *Cyrtoniodus complicatus* Stauffer, also a *Cordylodus*. Both *Prioniodus aculeatus* and *Prioniodus cristulus* Stauffer are species of *Cordylodus;* neither exhibits an anterior or lateral denticulated process. On the other hand, *C. multidentatus* and *C. quadratus* Graves & Ellison have laterally costate cusps and may be referable to *Gothodus* Lindström, rather than to *Cordylodus*. Lindström suggests (1954) that *Cordylodus plattinensis* Branson & Mehl may also be referable to *Gothodus*, but this is not substantiated by a study of typical representatives of that species in our collections. That is, there are no lateral ribs or costae on the cusp of this species, but the cusp is somewhat twisted so that the anterior and posterior costae appear to occupy a lateral position.

Cordylodus? delicatus Branson & Mehl is a valid *Cordylodus*, but we can see no way in which species such as *C. rectilineatus* (Stauffer), *C. aculeatus* (Stauffer), *C. cristulus* (Stauffer), and *C. elongatus* Rhodes (*non* Stauffer) can be distinguished from it. We have not studied the types of all these species, hence we cannot be certain that they are all conspecific. However, there is little in the illustrations of their types to distinguish them from each other or from the illustrated type of *Cordylodus delicatus* Branson & Mehl, the first-published name for this group.

Cordylodus is not uncommon in rocks of Lower Ordovician age; it is abundantly represented in known Middle and early Upper Ordovician faunas, and one questionable representative had been illustrated (Branson, Mehl, & Branson, 1951) from Richmond strata of the type area. Four specimens, referred with question to *Cordylodus*, but apparently valid representatives of the genus, have been described (Rhodes, 1953) from the Aymestry limestone (lower Ludlow) of Shropshire. This occurrence appears to be the youngest; valid representatives of the genus are not known to occur in younger rocks.

CORDYLODUS DELICATUS Branson & Mehl
Pl. 132, figs. 12,14,17

Cordylodus? delicatus BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 129, pl. 10, figs. 14,15; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 82; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 732, pl. 88, fig. 5.

Subcordylodus delicatus BRANSON, 1944, Missouri Univ. Studies, v. 19, p. 89,90, pl. 13, figs. 17,18; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 194; ETHINGTON, Jour. Paleontology, v. 33, 1959, p. 288, pl. 41, fig. 13.

Cordylodus rectilineatus RHODES, 1953, Phil. Trans. Roy. Soc. London, ser. 3, no. 647, p. 300,301, pl. 22, figs. 172–175.

Cordylodus elongatus RHODES. 1953, ibid., p. 299, pl. 21, figs. 114–118 [not *Cordylodus elongatus* (Stauffer)].

Cusp long, laterally compressed, anteriorly and posteriorly keeled (or costate), proclined proximally, but erect or slightly recurved distally. Anterior costa or keel deflected toward inner side in its lower half, forming, in many representatives, a somewhat expanded flange. Posterior costa continuous with delicate, bowed, elongate posterior process, the upper surface of which bears 8 to 10 laterally compressed, sharp-pointed, posteriorly inclined denticles that may be partially confluent near their junction with the basal element of the process. Basal excavation consists of a relatively deep, conical concavity beneath the cusp, continuous with a tapering groove that ex-

tends beneath the full length of the posterior process. Sheath of basal excavation thin-walled, somewhat laterally expanded beneath the cusp on the inner side.

Remarks.—Only two of the specimens in our Eden collection preserve a complete posterior process, a condition that seems to obtain in a majority of the previously described representatives of this species. The species is distinct, however, by virtue of the laterally deflected anterior costa. Conodont-elements referred by Stauffer and others to *Subcordylodus* (or *Cordylodus*) *rectilineatus* are perhaps somewhat more strongly bowed than typical *Cordylodus delicatus;* otherwise, we can see no way to distinguish them from the specimens at hand or from the types of *C. delicatus.* The types of *C. elongatus* Rhodes (not Stauffer) from the Gelli-grin limestone of Wales are said (Rhodes, 1953) to differ from *C. delicatus* Branson & Mehl only in that the lower inward extension of the cusp is markedly, rather than only slightly, recurved. We doubt that this is a particularly objective difference, especially because the types of *C. delicatus* exhibit some variation in this respect.

Occurrence.—Representatives of this species occur in all units at each locality sampled.

Types.—Figured hypotypes, OSU 22180, 22182, 22185; unfigured hypotypes, OSU 21462, 21463, 21464, 21465, 22124, 22125.

Cordylodus flexuosus (Branson & Mehl)
Pl. 132, fig. 13

Prioniodus? flexuosus Branson & Mehl, 1933, Missouri Univ. Studies, v. 8, p. 130, pl. 10, fig. 16; Fay, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 171.

Cyrtoniodus complicatus Stauffer, 1935a, Geol. Soc. America, Bull. v. 46, p. 140,158, pl. 11, figs. 44,46,48–51; Fay, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 85; Rhodes, 1953, *Phil. Trans. Roy. Soc. London,* Ser. B., no. 647; p. 302, pl. 22, figs. 193–196; Sweet, 1955, Jour. Paleontology, v. 29, p. 254, pl. 28, fig. 3; Glenister, 1957, Jour. Paleontology, v. 31, p. 732, pl. 88, fig. 16; Ethington, 1959, Jour. Paleontology, v. 33, p. 274, pl. 40, fig. 7.

Laterally bowed conodont-elements, characterized by an arched base surmounted anteriorly by a wide, erect, laterally compressed, sharp-edged cusp, and posteriorly by a denticulated process of considerable length. The anterior and posterior margins of the cusp are sharp and, in some specimens indistinctly keeled or costate. The posterior margin of the cusp joins the denticulated edge of the posterior process at about right angles. The base is deeply excavated; at the anterior end of the excavation, there is a slight expansion of the upper margin of the cavity to form a subconical space, the apex of which lies directly beneath the point at which the cusp and the posterior process join. The posterior process is excavated by a relatively shallow groove for the full extent of its length. The sheath of the basal cavity flares laterally on the inner side of the element, but it is not expanded on the outer side of the base.

Remarks.—Rhodes (1953) noted the similarity between Branson & Mehl's *Prioniodus? flexuosus* and Stauffer's *Cyrtoniodus complicatus* and pointed out that the two species are probably conspecific. The types are of somewhat different age, but we believe that they are clearly representatives of the same characteristic type of conodont-element. Furthermore, both fall well within the limits of *Cordylodus* as that genus is herein interpreted.

Occurrence.—Abundant in nearly every Eden sample.

Types.—Figured hypotype, OSU 22186; unfigured hypotypes, OSU 21461, 22126, 22127.

Cordylodus excavatus, n. sp.
Pl. 132, fig. 16

Diagnosis.—A robust species of *Cordylodus* with a massive erect cusp, cardioid to subtriangular in cross section and longitudinally grooved posteriorly for at least the proximal third of its length. Cusp groove extended for a short distance along upper surface of posterior process; balance of process bears several large, discrete, posteriorly inclined denticles of essentially circular cross section. Base deeply excavated.

Description.—Units thick and massive. Cusp long, erect above base; proximal cross section heart-shaped, distal cross section subtriangular. Anterior margin of cusp acutely rounded, sharp, or faintly keeled; posterior edge longitudinally grooved in its proximal third, flat or slightly concave in its

distal two-thirds. Posterior process thick and of unknown length, but probably long; posterior cusp groove extends for a short distance along upper surface of process. Balance of process bears closely spaced, discrete, slightly compressed or essentially subcircular denticles, inclined uniformly toward the posterior. Downward extension of cusp posteriorly recurved, faintly keeled or costate in some specimens; forms angle of approximately 45 degrees with posterior process. Basal excavation deep; subconical cavity beneath cusp; apex slightly anterior to cusp mid-line. Sheath lamellae thick; outer lamella moderately convex; inner lamella gently convex to nearly flat.

Remarks.—The heart-shaped cross section of the cusp of this new species serves to distinguish it from previously described representatives of *Cordylodus*.

Occurrence.—Rare in McMicken member of the Eden, at localities 13100, 13103, 13105, 13107.

Types.—Holotype, OSU 22183; paratypes, OSU 22184 (8 specimens).

Genus DICHOGNATHUS Branson & Mehl, 1933
Type species: *Dichognathus prima* Branson & Mehl, 1933

Paired, individually asymmetrical, blade-like conodont-elements. Posterior edge of cusp produced into a laterally compressed, denticulated process; anterior edge non-denticulate and, in most species, forms a distinct marginal flange. From the lower part of the inner margin of the cusp is produced a downwardly-directed lateral process, in many species continuous with a more or less well defined lateral costa on the cusp. Posterior and inner lateral processes excavated; these slot-like excavations join beneath the cusp forming a conical or subconical cavity, the sheath of which is more or less inflated on the inner side.

For descriptive purposes, these elements are oriented as shown in figures 2 and 3, Plate 132. Figure 2 illustrates the outer side of a typical element; figure 3 is a view of the inner side of a similar specimen. The posterior process is oriented horizontally; the lateral process defines the inner lateral side. The angle between the inner lateral process and anterior cusp edge is termed the "outer process angle."

Remarks.—*Dichognathus* is closely similar to *Prioniodus* Pander, differing from it only in that the anterior edge of the cusp is not produced into a denticulate process. *Loxognathus* Graves & Ellison is regarded by Ellison (1946) as a synonym of *Dichognathus;* its type species, *L. flabellata*, appears to be a *Dichognathus* in which the outer process angle is greater than 90° (about 120° according to the type description). Müller (1956) tentatively refers the species included in *Gothodus* Lindström (1954) to *Dichognathus*, but we cannot accept this suggestion. *Gothodus* includes virtually symmetrical conodont-elements characterized by a tri-costate cusp, only one costa (the posterior one) being produced into a denticulate process.

We are excluding from *Dichognathus*, *D. peculiaris* Stauffer, from the Glenwood beds of Minnesota, and *D. polita* and *D. protexa* Stauffer, both from Devonian clay admixtures in Minnesota, for all three species have three denticulate processes and appear to belong in *Prioniodus* Pander.

The type species of *Dichognathus*, *D. prima*, is from the Middle Ordovician (Wilderness?) Harding sandstone of Colorado; other representatives of the genus are known from rocks of presumably comparable age in North America and Europe, but the genus does not become a conspicuous element of conodont faunas until late in the Middle Ordovician and early in the Upper Ordovician. *Dichognathus* appears to be characteristic of the North American mid-continent faunal province, even though occasional specimens are found in rocks of the Anglo-Scandinavian province. No valid representatives of the genus are known from rocks of post-Maysville age.

Branson & Mehl (1933) remark that the abundance of *Dichognathus* in their Plattin limestone collections made specific segregation difficult. They also note that representatives of the genus are highly variable, but that it was not difficult to arrange completely gradational morphological series. Nevertheless, they describe distinctive "form-trends" as separate species, even through they candidly admit that it was sometimes " . . . difficult to decide to which

species a given specimen should be referred."

We have encountered similar problems in attempting to determine the relationships of the many representatives of *Dichognathus* in our Eden collections. All our specimens are closely related morphologically, not only to each other, but also to the several "form-trends" described by Branson & Mehl as distinct species. As a group, our specimens can be distinguished from the several Plattin species only in that the cusps tend to be somewhat larger and longer and the process denticles appear to be larger and more distinctly discrete. The outer process angle (lateral offset of Branson & Mehl, 1933) is a rather variable feature; however, we have subdivided our specimens primarily on the basis of the size of this angle and we are assigning the resulting groups to three of Branson & Mehl's Plattin species. We do this somewhat hesitantly, for there are forms intermediate between all three categories; the groups recognized might perhaps be best regarded as variants of a single species.

DICHOGNATHUS BREVIS Branson & Mehl
Pl. 132, fig. 7

Dichognathus brevis BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 113, pl. 9, figs. 24–26; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 86; SWEET, 1955, Jour. Paleontology, v. 29, p. 258, pl. 28, fig. 14; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 734, pl. 88, figs. 10,12,

Eden specimens referred to this "trend-species" are similar to the types in that they have short posterior and inner lateral processes and a relatively large straight cusp. The outer process angle is between 35 and 45 degrees and, in lateral view, the distal margins of the process excavations appear to meet beneath the cusp at an angle of about 90 degrees. The cusp is at least half again as long as either process; it is laterally compressed, has sharp anterior and posterior edges, is subtriangular in cross section, and tapers rather abruptly distally to a spatulate point. The outer face of the cusp is broadly convex; the inner face consists of anterolateral and posterolateral planes that intersect near mid-width to form a rounded costa, broadly continuous with the denticulate edge of the inner lateral process. Process denticles are low, sharp-pointed, and discrete above their bases. The basal excavation forms a deep conical cavity beneath the cusp and the proximal parts of the processes; the excavation is continuous the full length of both processes, but decreases markedly in height toward their distal ends. On the outer side of the cusp and processes, the basal sheath forms a plane, whereas on the inner side, it flares rather broadly beneath the cusp axis.

Occurrence.—Abundant in Fulton-Economy and Southgate members; common in McMicken member at all localities.

Types.—Figured hypotype, OSU 21440; unfigured hypotypes, OSU 22209, 21441, 22129.

DICHOGNATHUS EXTENSA Branson & Mehl
Pl. 132, fig. 2,3

Dichognathus extensa BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 114, pl. 9, fig. 21; FAY, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, 1952, p. 86; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 734, pl. 88, figs. 11, 17.

?Dichognathus cf. *extensa* SANNEMANN, 1955, Neues Jahrb. Geol. Paläont., Abh., Bd. 102, p. 25, pl. 2, fig. 12.

We are referring to this species several Eden specimens distinguished by relatively long processes of moderate height and an outer process angle of 10 degrees or less. The cusp is of variable size and length, but in all our specimens it is erect, laterally compressed, has sharp anterior and posterior edges, and is broadly (but asymmetrically) subtriangular in transverse section. The flange-like anterior margin of the cusp turns outward slightly proximally. The sharp posterior margin is continuous with the denticulate margin of the posterior process. A broad longitudinal costa formed by the intersection of posterior and anterior planes of the inner cusp face is continuous basally with the denticulate margin of the inner lateral process. The processes are rather long, subequal in length, laterally compressed, and excavated basally for their entire length. The basal excavation is relatively deep and subconical in lateral view beneath the cusp; it diminishes regularly in height toward the ends of the processes. The basal sheath is somewhat concave beneath the cusp on the outer side, but flares broadly beneath the cusp on the inner side.

Remarks.—Insofar as we can determine, this species is distinguishable from *Dichognathus typica* Branson & Mehl only in that the outer process angle is small and the entire unit is blade-like in form. Our collections include a number of forms transitional, in the size of the outer process angle, between *D. extensa* and *D. typica*, and we are inclined to suspect that there is little justification for specific subdivision of this more or less continuous series.

Occurrence.—Common in all members of the Eden at all localities sampled.

Types.—Figured hypotypes, OSU 21438, 21439; unfigured hypotypes, OSU 21437, 22132, 22215, 22213, 22212, 22210.

DICHOGNATHUS TYPICA Branson & Mehl
Pl. 132, fig. 6

Dichognathus typica BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 113,114, pl. 9, figs. 27–29; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 86; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 735, pl. 88, figs. 4,6; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 274, pl. 40, fig. 17.

?Dichognathus cf. *D. typica* RHODES, 1953, Phil. Trans. Roy. Soc. London, ser. B, no. 647, p. 317, pl. 22, figs. 178–180; SANNEMANN, 1955, Neues Jahrb. Geol. Paläont., Abh., Bd. 102, p. 25, pl. 2, fig. 13.

This species, abundantly represented in the Eden of Ohio, is characterized by rather deeply excavated processes of subequal length and by an outer process angle of 20–30 degrees. The cusp is somewhat variable in length and width, but in most of our forms it is erect, parallel-sided proximally, bluntly pointed distally, and approximately equivalent to the posterior and inner lateral processes in length. In most comparable features, these elements resemble *Dichognathus extensa*, but the basal excavation is deeper and the outer process angle is considerably larger.

Occurrence.—Common throughout the Eden at all localities sampled.

Types.—Figured hypotype, OSU 21436; unfigured hypotypes, OSU 21442, 22128, 22214, 22211.

Genus DREPANODUS Pander, 1856
Type species: *Drepanodus arcuatus* Pander, 1856

Pander's (1856) diagnosis of this genus is as follows: "Mehr oder weniger gekrümmte spitze Zähne, mit vorderen und hinteren gleich grossen scharfen Kielen und convexen, glatten, symmetrischen Seitenflächen."

As thus delineated, *Drepanodus* would seem restricted to symmetrical simple cones, costate on their anterior and posterior edges, but unmarked laterally or otherwise by costae. Pander, however, included in *D. arcuatus*, regarded since 1889 as the type of the genus, a bewildering variety of simple cones, not all of which seem to fall within *Drepanodus* as he defined it. Recognizing this, Lindström (1954) has excluded from *Drepanodus arcuatus* forms comparable to those Pander illustrated in figures 2, 17, 30, and 31 on his Plate 1, and restricted that species to forms like Pander's figures 4 and 5 on the same plate. If the type species is thus defined, *Drepanodus* seems confined to symmetrical (or essentially symmetrical) simple cones with smooth lateral faces and sharp anterior and posterior edges. Forms in which the posterior margin of the cusp joins the upper margin of the basal sheath in a sharp angle are, following Lindström, referred to *Oistodus;* in *Drepanodus*, the posterior margin of the cusp joins the upper margin of the basal sheath in a smooth curve.

Drepanodus occurs in rocks that range in age from Lower Ordovician (Tremadoc) to Lower Silurian. Although many species, as now conceived, have a long extent within the range of the genus as a whole, it is suspected that refinement of specific concepts will result in narrower stratigraphic limits for most species; they may eventually be very useful guide, or zonal fossils.

DREPANODUS? ALTIPES Henningsmoen?
Pl. 130, fig. 1

?Drepanodus altipes HENNINGSMOEN, 1948, Geol. Inst. Upsala, Bull., v. 32, p. 420, pl. 25, fig. 14; RHODES, 1953, Phil. Trans. Geol. Soc. London, ser. B, no. 647, p. 292, pl. 21, figs. 102–105; RHODES, 1955, Quart. Jour. Geol. Soc. London, v. 111, p. 125, pl. 10, figs. 6,8,29.

We have a single specimen from the Economy member of the Eden that almost certainly belongs in this species. It is a laterally compressed simple cone that is markedly, but apparently rather regularly recurved above the base and somewhat twisted toward the inner side distally. The posterior and anterior margins of the cusp are promi-

nently costate for their full length; in proximal portion of the anterior margin, the costa is very wide, occupying virtually a third the width of the sheath of the basal cavity. The lateral faces are markedly convex; however, the convexity of the inner face is subdivided by a low, sharp-edged ridge that extends distally to a point about opposite the place where the upper edge of the basal sheath joins the posterior margin of the cusp. The basal cavity is deep and conical in shape.

Remarks.—This specimen is similar in overall appearance to the figured type of *Drepanodus altipes* Henningsmoen, and may well belong in that species. However, the anterior keel is much wider basally than in the Swedish material and the cusp itself seems to be somewhat twisted distally. We are not certain how much weight should be attached to such variations, and, since we have only one specimen, we are referring it to Henningsmoen's species with question. It should also be noted that, at least basally, elements referable to *D. altipes* are not symmetrical. Apparently, though, the lateral rib disappears distally so that the cusp cross section is essentially symmetrical at mid-length. Our specimen does not preserve this much of the cusp. It is possible that this basal asymmetry is sufficient to suggest reference of the species *altipes* Henningsmoen to *Acodus;* our material does not permit us to draw any such conclusion.

Occurrence.—The only known Eden specimen comes from the Economy member at locality 13095.

Type.—Figured hypotype, OSU 21423.

DREPANODUS HOMOCURVATUS Lindström
Pl. 130, fig. 7

Oistodus curvatus BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 110,111, pl. 9, figs. 4,10,12; STAUFFER, 1935a, Geol. Soc. America, Bull. v. 46, p. 146,159, pl. 12, figs. 20,23,27,29,30,36; STAUFFER, 1935b, Jour. Paleontology, v. 9, p. 609, pl. 74, figs. 5,10,12; FURNISH, BARRAGY, & MILLER, 1936, Amer. Assoc. Petroleum Geologists, Bull., v. 20, p. 1334, pl. 1, fig. 8; pl. 2, figs. 17,18; GRAVES & ELLISON, 1941, Missouri School Mines & Metallurgy, Bull., Tech. Ser., v. 14, p. 4,6,7, pl. 1, fig. 8; pl. 3, figs. 17,21,27; AMSDEN & MILLER, 1942, Jour. Paleontology, v. 16, p. 303, fig. 2B; BRANSON, 1944, Missouri Univ. Studies, v. 19, p. 81,89, pl. 11, figs. 8,25,31; pl. 12, figs. 37,38; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 134; RHODES, 1953, Phil. Trans. Roy. Soc. London, ser. B, no. 647, p. 295, pl. 21, figs. 82,89, 90, pl. 22, figs. 157–161; SWEET, 1955, Jour. Paleontology, v. 29, p. 251, pl. 28, fig. 7.

Drepanodus homocurvatus LINDSTRÖM, 1954, Geol. Fören. (Stockholm) Förhandl., bd. 76, p. 563, pl. 2, figs. 23,24,29, text-fig. 4d; SANNEMANN, 1955, Neues Jahrb. Geol. Paläont, Abh., Bd. 102, p. 26, pl. 2, fig. 4; pl. 1, fig. 14; LINDSTRÖM, 1957, Geol. Fören. (Stockholm) Förhandl., bd. 79, p. 164; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 725, pl. 86, fig. 13; pl. 87, figs. 1–6,8; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 276, pl. 39, fig. 16.

This species has been adequately discussed by Lindström (1954) and others and we can add little to their observations from a study of the material at hand. Our specimens compare so favorably with the types and other illustrated representatives of this widespread and distinctive species that we are referring them to it without question.

Lindström proposed this name for the species long recognized as *Oistodus curvatus* Branson & Mehl (1933) for, upon transferring this species to *Drepanodus*, which we believe proper, the older name became a junior homonym of *Drepanodus curvatus* Stauffer, 1932.

Occurrence.—Representatives of *Drepanodus homocurvatus* constitute about 2% of our collections from the Fulton-Economy, some 7% of our Southgate conodonts, and about 5% of the conodonts at hand from the McMicken member of the Eden. At least a few specimens have been found in all units sampled at every locality.

Types.—Figured hypotype, OSU 22167; unfigured hypotypes, OSU 21427, 22137, 22168, 22169.

DREPANODUS SUBERECTUS (Branson & Mehl)
Pl. 130, fig. 4

Oistodus suberectus BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 111, pl. 9, fig. 7; STAUFFER, 1935a, Geol. Soc. America, Bull., v. 46, p. 147, 159, pl. 12, figs. 14,19,28,31,35; STAUFFER, 1935b, Jour. Paleontology, v. 9, p. 611, pl. 74, figs. 18,42,46; FURNISH, BARRAGY, & MILLER, 1936, Jour. Paleontology, v. 12, p. 1334, pl. 1, fig. 9; GRAVES & ELLISON, 1941, Missouri School Mines & Metallurgy, Bull., Tech. Ser., v. 14, p. 4,7, pl. 1, fig. 32; BRANSON & MEHL, 1943, Jour. Paleontology, v. 17, p. 376,385, pl. 64, fig. 16; BRANSON, 1944, Missouri Univ. Studies, v. 19, p. 89,90, pl. 13, fig. 40; BRANSON, MEHL, & BRANSON, 1951, Jour. Paleontology, v. 25, p. 8,9, pl. 2, figs. 1–4;

FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 136; RHODES, 1953, Phil. Trans. Roy. Soc. London, ser. B, no. 647, p. 295, pl. 21, figs. 93,94; pl. 22, figs. 166,167; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 726, pl. 86, figs. 12,14.

Drepanodus suberectus LINDSTRÖM, 1954, Geol. Fören. (Stockholm) Förhandl., bd. 76, p. 568, pl. 2, figs. 21,22; SANNEMANN, 1955, Neues Jahrb. Geol. Paläont., Abh., 3d. 102, p. 27, pl. 1, fig. 22; pl. 2, fig. 1; LINDSTRÖM, 1957, Geol. Fören. (Stockholm) Förhandl., bd. 76, p. 164; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 276, pl. 39, fig. 17.

Remarks.—This species is distinctive and the specimens at hand are clearly referable to it. Like *Drepanodus homocurvatus*, it seems to represent one of the more conservative elements of the conodont animal, for specimens referable to the species on the basis of form, at least, are known from strata at many different levels within the Ordovician of both the Anglo-Scandinavian-Appalachian and North American midcontinent provinces.

Occurrence.—Conodont-elements of this species constitute about one percent of our Eden collections: this percentage is maintained in each member.

Types.—Figured hypotype, OSU 22141; unfigured hypotypes, OSU 21425, 22174.

Genus EOBELODINA, n. gen.

Type species: *Oistodus fornicalus* Stauffer, 1935

Name.—From "*eos*" (Gr.), early, and "*Belodina*" Ethington. Hence, an early, or primitive *Belodina*.

Diagnosis.—Bowed, individually asymmetrical, simple conodont elements, with massive, erect, longitudinally striated cusp, compressed in cross section. Upper margin of base produced into stout compressed flange-like "heel," the anterior end of which joins the posterior cusp margin in an acute angle. Base only slightly expanded on inner side, "crimped" along posterior margin, and constructed horizontally near mid-height so that the capacious, asymmetrically subconical excavation is divided into two interconnected cavities. Thread-like extension of basal excavation apex in lower subdivision.

For descriptive surposes, these elements are oriented with the cusp and basal "heel" upright and the posterior margin vertical.

Remarks.—*Oistodus fornicalus* Stauffer, a not uncommon species in Middle and early Upper Ordovician rocks of the North American midcontinent, has only a gross superficial resemblance to typical *Oistodus*, as we interpret that genus. The posterior margin is bent inward, the basal excavation is deep, capacious, and imperfectly bifid, and the surface of the entire element is finely striated. All these characters occur also in *Belodina* Ethington, in which, however, the posterior (or concave) margin of the cusp is produced into a series of distinct denticles. At first, we suspected that *Oistodus fornicalus* included immature specimens of *Belodina*. This hypothesis was rejected, however, for there is no structural pattern evident in any of our representatives of either group to indicate that the type of growth necessary to produce a *Belodina* from *Oistodus fornicalus* actually took place. We are, therefore, referring Stauffer's species to a new genus, clearly related to *Belodina*, but formally distinguished from it by the absence of denticles on the concave, or posterior cusp margin and an imperfect subdivision of the basal cavity into two elements.

EOBELODINA FORNICALA (Stauffer)
Pl. 133, fig. 11

Oistodus fornicalus STAUFFER, 1935b, Jour. Paleontology, v. 9, p. 610, pl. 75, figs. 3–6; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 135; LINDSTRÖM, 1954, Geol. Fören. (Stockholm) Förhandl, bd. 76, p. 573; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 282, pl. 39, fig. 19.

(non) *Oistodus fornicalus* GRAVES & ELLISON, 1941, Missouri Univ. School Mines & Metallurgy, Bull., Tech. Ser., v. 14, p. 4,7, pl. 1, figs. 15,17.

?Belodus? sp. BRANSON, 1944, Missouri Univ. Studies, v. 19, pl. 12, figs. 12,13.

Cusp massive, erect or slightly reclined, compressed, with sharp, blade-like anterior and posterior edges. Inner lateral face marked by median longitudinal rib or costa; outer face flat or broadly convex. Both faces marked by prominent longitudinal striations that are subparallel to the curving axis of the cusp, but not parallel to its anterior edge, which they intersect obliquely. Base of cusp produced posteriorly; the upper edge of the base occupied by a stout, compressed, distally convex, flange-like "heel" that is continuous with the posterior margin of the cusp. Junction between cusp and

"heel" an acute angle. Posterior margin of base "crimped" or infolded; base proper deeply excavated by compressed, subconical cavity, imperfectly divided into upper and lower elements by a horizontal constriction of the inner basal sheath. Apex of basal cavity near mid-line of cusp, but apparently continued into axis of cusp as a fine, thread-like extension. Upper margin of basal cavity sigmoidal; apex included with lower subdivision of cavity.

Occurrence.—Not common in Eden conodont collections, but representatives have been found in samples from all three Eden members at localities 13093, 13095, 13099, 13100, 13104. Neither the species nor the genus is known to occur in the Fairview, McMillan, or Richmond group.

Types.—Figured hypotype OSU 22139; unfigured hypotypes, OSU 21424, 22172.

Genus EOLIGONODINA Branson, Mehl, & Branson, 1951

EOLOGONODINA ELONGATA (Rhodes)

Pl. 132, fig. 4

Ligonodina elongata RHODES, 1953, Phil. Tran. Roy. Soc. London, ser. B,. no. 647, p. 306, pl. 21, fig. 130,131; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 277, pl. 40, fig. 5.

We have two specimens from the Fulton-Economy and Southgate members of the Eden that seem to represent this species. These conodont-elements are composed of a large, erect or slightly recurved cusp, delicately costate anteriorly and posteriorly, and semicircular in cross section, the outer lateral face being only slightly convex, the inner lateral face being more prominently bowed. The anterior costa of the cusp curves inward at the cusp base and supports two large, sharp-edged, peg-like denticles directed forward and inward. Posterior cusp costa continous with row of about four denticles, arranged in hindeodelloid fashion, that is, with the largest near the center of the series. Under surface of unit deeply excavated; sheath of cusp cavity essentially flat on inner side, somewhat convex on outer side.

Remarks.—The specimens at hand compare almost exactly with the types of this species, hence they are referred to it without question. Rhodes (1953) would prefer to regard species of *Eoligonodina* as *Ligonodina* and correctly points out that *Eoligonodina* " . . . appears to differ from *Ligonodina* only in the development of a deep, subapical . . . cavity." Gross (1957) suggests that the deep, thin-walled subapical cavity of *Eoligonodina* may be a basal funnel (Basistrichter), but this suggestion is not borne out by a study of type material.

Eoligonodina and *Ligonodina* are certainly gradational, just as are Ordovician and later representatives of most bar- and blade-like genera in that Ordovician forms tend to have capacious attachment cavities, whereas later forms exhibit progressive reduction in these cavities through basal "inversion" (Lindström, 1954). We see little, if any way to distinguish between *Cordylodus* and *Neoprioniodus*, for example, other than to recognize that typical representatives of the former have deep, commodious basal cavities, whereas the attachment cavity of the latter has been reduced by "inversion" to a subapical navel or pit. We feel that much more study of intermediate forms is needed before any sweeping revisions are made in gradational groups like the ones these genera represent.

Occurrence.—Fulton-Economy member, locality 13097. Southgate member, locality 13093.

Genus KEISLOGNATHUS Rhodes, 1955

KEISLOGNATHUS GRACILIS Rhodes

Pl. 132, fig. 11

Keislognathus gracilis RHODES, 1955, Quart. Jour. Geol. Soc. London, v. 111, p. 131, pl. 7, figs. 7,8.

All of the specimens we are referring to this species are incomplete in some part, but they are similar in that they are compound conodont elements consisting of an erect to slightly reclined cusp, the posterior and inner lateral sides of which are produced into distinctly denticulated processes. A third process is developed on the outer side and joins the cusp only slightly to one side of its anterior edge. The cusp is asymmetrically subtriangular in cross section; its anterior margin is sharp, its inner face is broadly convex and bears a median lateral costa. The posterior margin of the cusp is acutely rounded. The outer face is asymmetrically convex and smooth. The posterior cusp margin is produced into a laterally compressed,

unbowed, apparently rather long process, the upper surface of which bears a number of discrete denticles that appear to alternate rather regularly in size: its under surface is deeply excavated longitudinally. The inner lateral process is a compressed, flange-like ridge that forms a direct continuation of the inner lateral cusp costa. This process is continued beneath the basal sheath of the cusp as a long, delicate, posteriorly curving bar, bearing on its outer side, low, discrete, denticles that are directed upward and forward distally. The outer lateral process consists of a single large denticle (incomplete distally in all of our specimens) that is circular in cross section and parallel and closely appressed to the cusp near its anterior edge. This lateral denticle is produced beneath the unit into a long, delicate, shallowly excavated process that curves posteriorly beneath the base.

Occurrence.—All of the specimens at hand were collected from the Fulton-Economy member of the Eden at locality 13095. *Keislognathus* is not known from the Southgate or McMicken members of the Eden, but a few delicate specimens have been found in the lowermost part of the superjacent Fairview formation.

Types.—Figured hypotype, OSU 21478; unfigured hypotypes, OSU 22206.

Genus OISTODUS Pander, 1856
Type species: *Oistodus lanceolatus* Pander, 1856

As Lindström (1954) and others have noted, a rather heterogeneous group of species characterized only by more or less expanded bases has been included in *Oistodus*. All the forms assigned to this genus by Pander are alike, however, in that they are laterally costate and the posterior edge of the cusp joins the upper edge of the expanded base in a sharp, acute angle. For these reasons, the writers agree with Lindström's restriction of *Oistodus* to simple conodont-elements with a more or less expanded basal cavity in which the posterior edge of the cusp makes a sharp, acute angle with the upper edge of the base. In most species, either or both cusp faces are costate.

Oistodus ranges from the Lower Ordovician (Tremadocian) into the Upper Ordovician and valid representatives of the genus as it is now interpreted, have been reported from three continents (Europe, Australia, and North America). Published descriptions suggest that the genus is more varied specifically in early than in middle or late Ordovician strata and that a greater number and diversity of oistodids occur in the Lower Ordovician of Europe than in rocks of comparable age in North America.

OISTODUS ABUNDANS Branson & Mehl
Pl. 130, fig. 3

Oistodus abundans BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 109, pl. 9, figs. 11,17; STAUFFER, 1935a, Geol. Soc. America Bull., v. 46, p. 146,159, pl. 12, fig. 22; STAUFFER, 1935b, Jour. Paleontology, v. 9, p. 609, pl. 75, figs. 2,7, 11–13; LOOMIS, 1936, Jour. Paleontology, v. 10, p. 664; STAUFFER, 1940, Jour. Paleontology, v. 14, p. 426, pl. 60, fig. 20; BRANSON & MEHL, 1943, Jour. Paleontology, v. 17, p. 376,386, pl. 64, fig. 11; BRANSON, 1944, Missouri Univ. Studies, v. 19, p. 79,80, pl. 11, figs. 26,38; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 134; SANNEMANN, 1955, Neues Jahrb. Geol. Paläont. Abh., Bd. 102, p. 4,28, pl. 2, fig. 8; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 725, pl. 86, fig. 5; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 282, pl. 39, fig. 21.

?Oistodus abundans GRAVES & ELLISON, 1941, Missouri Univ. School Mines & Metallurgy, Bull., Tech. Ser., v. 14, p. 4,7,14, pl. 2, figs. 19,20; IMBT, 1941, *in* Stratigraphic type oil fields, p. 148.

(non) *Oistodus abundans* RHODES, 1953, Phil. Trans. Roy. Soc. London, ser. B, no. 647, p. 294, pl. 21, figs. 91,92.

Cusp laterally compressed, reclined, forming an angle of about 45 degrees with base; distal extremity bowed somewhat inward Outer cusp face broadly convex; inner face more prominently so with anterior and posterior borders flat or slightly concave. Basal cavity asymmetrically subconical with posterior margin essentially parallel to upper edge of base; anterior margin concave in longitudinal outline and apex located immediately beneath point at which upper edge of base joins posterior margin of cusp. Upper margin of basal sheath produced into prominent flange-like blade; anterior and posterior extremities of basal sheath pointed, sheath gently convex on outer side, sharply convex at mid-length on inner side.

Remarks.—All our specimens are incomplete distally, but their identity is certain. The species belongs in a group of laterally asymmetrical oistodids typified by *Oistodus*

inaequalis Pander. In Pander's species, however, the inner cusp face is marked by an angular costa and the upper margin of the basal sheath does not appear to be produced into a blade. Inasmuch as the specimens referred by Rhodes (1953) to *O. abundans* do not appear to possess the broadly rounded inner lateral costa we regard as important in the delineation of this species, his specimens are here exluded from *O. abundans*.

Occurrence.—Nine to 13% of the specimens in our collections from the Fulton-Economy, Southgate, and McMicken members are referable to this species. Only a few samples failed to yield at least one identifiable representative.

Types.—Figured hypotype, OSU 22136; unfigured hypotypes, OSU 21426, 21428, 22166.

OISTODUS EXCELSUS Stauffer
Pl. 130, fig. 5

Oistodus excelsus STAUFFER, 1935b, Jour. Paleontology, v. 9, p. 610, pl. 74, fig. 43; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 136; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 725–726, pl. 86, figs. 4,7; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 282, pl. 39, fig. 20.

This species is characterized by a straight, laterally compressed, distally twisted cusp that joins the compressed, anteriorly upturned base at an angle of 35 to 40 degrees. Both the anterior and posterior margins of the cusp are costate and the anterior edge of the anterior costa curves inward near its proximal end. The base is approximately half the length of the cusp. The basal cavity is shallow, extends from the posterior to the anterior extremities of the base, and has its apex slightly anterior of the place at which the upper edge of the base and the posterior margin of the cusp join. The upper margin of the basal sheath is virtually straight and is developed into a flange of only minor height. The lower margin of the sheath is broadly convex, but turns rather abruptly toward the inside and upward near its junction with the anterior edge of the cusp. Both cusp faces bear rounded longitudinal costae, the inner one being more sharply defined than the outer one.

Remarks.—In form, at least, *Oistodus excelsus* seems most closely related to *O. parallelus* Pander and *O. forceps* Lindström. In both these species, however, the cusp has a tendency to be more strongly proclined and there is no indication in the descriptions or illustrations of their types that the forward costa of the cusp is twisted so markedly inward proximally.

Occurrence.—Representatives of this species constitute slightly less than one percent of our collections from the Southgate and McMicken members of the Eden, at all localities sampled.

Types.—Figured hypotype, OSU 22171; unfigured hypotypes, OSU 22138, 22170.

OISTODUS INCLINATUS Branson & Mehl
Pl. 131, fig. 6

Oistodus inclinatus BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 110, pl. 9, fig. 8; STAUFFER, 1935a, Geol. Soc. America, Bull., v. 46, p. 147, 159, pl. 12, fig. 21; STAUFFER, 1935b, Jour. Paleontology, v. 9, p. 610,611, pl. 74, fig. 41, pl. 75, figs. 9,14; FURNISH, BARRAGY, & MILLER, 1936, Amer. Assoc. Petroleum Geologists, Bull., v. 20, p. 1334, pl. 1, fig. 7, pl. 2, fig. 19; FURNISH, 1938, Jour. Paleontology, v. 12, p. 320,330, pl. 41, fig. 18; GRAVES & ELLISON, 1941, Missouri Univ. School Mines & Metallurgy, Bull., Tech. Ser., v. 14, p. 5,7, pl. 2, fig. 16 (*not* pl. 3, fig. 18, which does not appear to be an *Oistodus*); BRANSON & MEHL, 1943, Jour. Paleontology, v. 17, p. 376,386, pl. 64, fig. 1; BRANSON, 1944, Missouri Univ. Studies, v. 19, p. 79,80, pl. 11, fig. 16; BRANSON, MEHL, & BRANSON, 1951, Jour. Paleontology, v. 25, p. 3, pl. 2, figs. 5,6; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 135; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 726, pl. 86, fig. 11.

?Oistodus inclinatus SANNEMANN, 1955, Neues Jahrb. Geol. Paläont. Abh., Bd. 102, p. 28, pl. 1, figs. 23,24.

Cusp long, pointed, nearly straight, somewhat twisted longitudinally, reclined at angle of about 45 degrees with base; in cross section, outer face broadly convex with flattened anterior and posterior margins. Basal cavity relatively shallow, opening toward inner side. Basal sheath extended posteriorly, its upper margin sharp, but apparently not produced into a blade; sheath gently convex toward outer side, but flaring broadly on inner side.

Remarks.—Simple cones referable to *Oistodus inclinatus* can be distinguished from *O. abundans*, with which they occur, by the fact that the upper surface of the basal sheath is not produced into a blade, the

sheath is more broadly flaring on the inner side, and the extremities of the base are not so markedly produced. In addition, the cusp of *O. inclinatus* appears to be somewhat twisted toward the inner side, rather than bowed (as in *O. abundans*) and the basal cavity appears to open more toward one side in *O. inclinatus* than in *O. abundans*.

Occurrence.—Representatives of this distinctive species constitute about 1.5% of the total of our collections from the Fulton-Economy, Southgate, and McMicken members of the Eden. Specimens were collected from most units at every locality sampled.

Types.—Figured hypotype, OSU 22173; unfigured hypotypes, OSU 21430, 22140.

Genus OULODUS Branson & Mehl, 1933
Type species: *Oulodus mediocris* Branson & Mehl, 1933

Paired, individually asymmetrical compound conodont-elements with a massive, reclined and somewhat twisted cusp, the costae of which are continuous laterally with discretely denticulated processes of varying length and development. One process (here termed antero-lateral) is produced slightly downward and forward from the expanded cusp base; its upper surface bears a number of discrete denticles that ordinarily incline to the posterior. Opposite process (here designated postero-lateral) produced outward and downward proximally, but curving toward the posterior in its distal portion; upper surface with erect or slightly recurved, peg-like denticles. Under surface of entire element broadly, but not deeply excavated; sheath flares widely beneath posterior cusp margin to form lip of varying prominence.

The cusp is oriented so that its concave margin and lipped basal expansion are posterior. The more or less well developed cusp costae are then lateral (although they may twist distally with the cusp to assume a more or less anterior-posterior position) and the two processes are antero-lateral and postero-lateral.

Remarks.—*Gyrognathus* Stauffer (1935a) is clearly the same as *Oulodus* as Ellison (1946) notes and our re-examination of Stauffer's types indicates. Species referred by Rhodes (1953) and Ethington (1959) to *Gyrognathus* belong in *Zygognathus* Branson, Mehl, & Branson.

Oulodus primus (Stauffer), from the Glenwood and Decorah formations of Minnesota includes the earliest known representatives of the genus. In this species, the antero-lateral process is not as markedly recurved anteriorly as in *O. mediocris*. *O. planus* (Stauffer) from the Decorah shale of Minnesota is not as massive as either *O. primus* or *O. mediocris*, although it apparently came from rocks in general equivalent to those that yielded the types of the latter. A specifically indeterminate fragment from the Liberty formation (Richmond group) of the Cincinnati region (Branson, Mehl, & Branson, 1951) is the youngest *Oulodus* known. The genus is apparently not common in Wilderness and Trenton rocks, nor is it yet known from early Eden (Fulton-Economy) strata in the type area. Single representatives occur in both the Southgate and McMicken members of the Eden, however, and there is a "flood" of *Oulodus* in the superjacent Fairview formation. No valid representatives of *Oulodus* are yet known from rocks of the Anglo-Scandinavian or Appalachian provinces; a new species of the genus, *O. rohneri*, has recently been described (Ethington & Furnish, 1959) from the Shammattawa limestone of northern Manitoba, which is perhaps Maysvillian in age.

OULODUS MEDIOCRIS Branson & Mehl?
Pl. 133, fig. 5

?Oulodus mediocris BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 116, pl. 10, figs. 8,9.

We have two specimens from the Southgate and McMicken members of the Eden that are similar to the types of *Oulodus mediocris* but are too incomplete to be referred to that species with certainty. Both of these specimens are similar in that they have an erect to slightly reclined, distally twisted cusp that is subcircular in cross section and laterally costate. One cusp costa is continuous antero-laterally with a wide, downcurved, anteriorly deflected process, incomplete distally in both specimens. The upper surface of this process is set with discrete, peg-like, slightly reclined denticles. The opposite cusp costa is continued basally as a wide, essentially horizontal process that curves slightly to the posterior distally. This

process, although incomplete in both specimens, was clearly shorter than the antero-lateral one its upper surface bears two or three discrete, somewhat compressed denticles. The under surface of each process is shallowly excavated, but this excavation (or attachment surface) is broad and becomes progressively deeper toward the junction of the process with the cusp. The basal sheath is thin, only slightly convex anteriorly; posteriorly, the sheath is somewhat thicker and is broadly expanded, or "flared" beneath the cusp so that the attachment surface appears to face posteriorly. The lower anterior margin of the sheath beneath the postero-lateral process appears to form an angle of some 100 degrees with the sheath margin beneath the antero-lateral process.

Remarks.—Insofar as the fragments at hand can be compared with the types of *Oulodus mediocris*, correspondence is good. It should be noted that our specimens seem to be somewhat less arched than the Plattin types; however, any such difference is probably meaningless in fragmentary material.

Occurrence.—Southgate and McMicken members, locality 13108.

Types.—Figured hypotype, OSU 22223; unfigured hypotype, 22142.

Genus OZARKODINA Branson & Mehl, 1933
Type species: *Ozarkodina typica*
Branson & Mehl, 1933

This genus includes a majority of the arched, blade-like conodonts known, even though many species currently included in the genus are considerably different from the type species in form or stage of development. The type species comes from the Silurian Bainbridge formation of Missouri. It is based upon three incomplete cotypes, all of which are similar in that they are thin, slightly arched, denticulated blades, in which the denticles are laterally confluent and the crest of the arch is surmounted by a compressed denticle of superior width and height. Significantly, the lower edge of the blade is cuneate in transverse section, being only slightly excavated by a narrow groove that is continuous with a distinct navel beneath the cusp.

Ordovician forms referred to *Ozarkodina* by its authors and others have rather deep, thinly sheathed basal cavities, much more commodious and considerably more prominent than in the types of *O. typica;* in later Paleozoic forms, the attachment cavity is restricted entirely, or essentially to the subapical navel. Clearly, this evidences a trend in *Ozarkodina* toward an evolutionary reduction in the sheathed basal excavation by the progressive "inversion" of the lamellae that form its walls. A similar relationship probably exists between *Bryantodina* and *Ctenognathus;* between *Cordylodus* and typical *Neoprioniodus;* between *Eoligonodina* and *Ligonodina;* and perhaps between *Trichonodella* and *Hibbardella*. The end-members of any such series are distinct from one another and, for the most part, have been recognized as distinct genera. However, intermediate forms have always caused difficulties, and they tend to make arbitrary subdivision of the sequence meaningless.

We have experienced some difficulty in distinguishing formally between *Prioniodina*, also an arched blade, but based on late Devonian types, and *Ozarkodina*. In *Prioniodina subcurvata* Ulrich & Bassler, and a majority of the species subsequently referred to *Prioniodina*, the denticles are discrete and peg-like, whereas in typical *Ozarkodina*, adjacent denticles are confluent, and overgrown or "germ" denticles are common. Consequently, even though this distinction may eventually prove to be overly artificial, we are including in *Ozarkodina* only those of our arched, blade-like specimens in which the limb-denticles are compressed and laterally confluent. We are referring to *Prioniodina* several species of bar- or blade-like conodont-elements in which the limb-denticles are discrete and peg-like or not strongly compressed.

OZARKODINA ROBUSTA Stauffer
Pl. 132, figs. 19,20; Pl. 133, fig. 14

Ozarkodina robusta STAUFFER, 1935b, Geol. Soc. America, Bull., v. 46, p. 612, pl. 71, figs. 1,3,6,7,9–13,15,21; FURNISH, BARRAGY, & MILLER, 1936, Amer. Assoc. Petroleum Geologists, Bull. v. 20, p. 1334, pl. 1, fig. 14; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 138.

Remarks.—There is a great deal of variation exhibited by the representatives of *Ozarkodina* in our collections from the Eden of Ohio. Much of the variation in size, discreteness, sharpness, and number of den-

ticles seems to be a function of the growth stage represented by the individual specimen, hence, even though we cannot always demonstrate that we are not dealing with mature forms, we do not feel that much importance can be attached to these differences. In our specimens, however, the limbs of the blade join beneath the conspicuous, laterally compressed cusp at an angle of 130–135 degrees, the posterior limb tends to be somewhat shorter than the anterior, the denticles are subequal in larger specimens, and there is a tendency for the posterior limb to be twisted somewhat out of the general plane formed by the anterior limb. This seems to be the combination of characters Stauffer recognized when he erected *Ozarkodina robusta*, so it is to this species we are referring our Eden Ozarkodinas.

Occurrence.—About 2% of the 7,000 conodonts in our collections from the Fulton-Economy are referable to *Ozarkodina robusta*, whereas 10–13% of the nearly 3,000 specimens recovered from the Southgate and McMicken belong in this species. Well preserved specimens were found at nearly every horizon at every locality sampled.

Types.—Figured hypotypes, OSU 22145, 22225, 21453; unfigured hypotypes, OSU 21454, 21455, 21456, 21452, 22143, 22224, 22226, 22227, 22228.

Genus PANDERODUS Ethington, 1959
PANDERODUS GRACILIS (Branson & Mehl)
Pl. 131, fig. 1

Paltodus gracilis BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 108, pl. 8, figs. 20,21; FURNISH, BARRAGY, & MILLER, 1936, Am. Assoc. Petroleum Geologists, Bull., v. 20, p. 1335, pl. 1, fig. 3; FURNISH, 1938, Jour. Paleontology, v. 12, p. 324; GRAVES & ELLISON, 1941, Missouri Univ. School Mines & Metallurgy, Bull., Tech. Ser., v. 14, p. 5,7, pl. 2, fig. 5; BRANSON & MEHL, 1943, Jour. Paleontology, v. 17, p. 376,386, pl. 64, figs. 7,8; BRANSON, 1944, Missouri Univ. Studies, v. 19, p. 81,89, pl. 12, figs. 20–23; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 144; BRANSON, MEHL, & BRANSON, 1951, Jour. Paleontology, v. 25, p. 6, pl. 1, figs. 1–8; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 728, pl. 85, figs. 2–5.

Panderodus gracilis ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 285, pl. 39, fig. 1.

We are referring to this species simple, erect to distally recurved and somewhat twisted conodont-elements, characterized by a broadly rounded anterior margin, a sharp, costate posterior margin, and lateral faces marked longitudinally by sharp offsets that, in effect, form costae near mid-width on one side and on the antero-lateral corner of the opposed side. The basal cavity is deep, conical, somewhat laterally compressed, and fully half the length of the unit in height. The apex of the cavity lies slightly below the point of recurvature of the element and is rather close to the anterior margin.

Remarks.—The specimens at hand show some individual variation, but they are so similar to each other and to previously described representatives of *Panderodus gracilis* that they are referred to that species without question.

Occurrence.—Southgate and McMicken members, Eden formation, localities 13100, 13104. Rare in both members.

Types.—Figured hypotype, OSU 22176; unfigured hypotypes, OSU 22147, 22175.

PANDERODUS INTERMEDIUS (Branson, Mehl, & Branson)
Pl. 130, fig. 2

Paltodus intermedius BRANSON, MEHL, & BRANSON, 1951, Jour. Paleontology, v. 25, p. 7, pl. 1, figs. 9–15; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 728, pl. 85, fig. 10.

Panderodus intermedius ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 285, pl. 39, fig. 3.

A simple, recurved cone that appears to be somewhat twisted distally. Anterior face broadly rounded; posterior margin sharp-edged, somewhat deflected toward one side. Outer face smooth, flat in the posterior two-thirds of its width, but sharply deflected outward at the antero-lateral corner to form a prominent longitudinal costa. Inner face costate at about mid-width; posterior half convex outward, but grading through a narrow concave zone into the sharp-edged posterior margin. Basal cavity conical, somewhat compressed, with apex close to anterior margin and slightly below point of maximum recurvature of the element.

Remarks.—The only representatives of this species in our collections differ somewhat from the types of *Panderodus intermedius*, but are so like them in other respects (particularly in mid-length transverse section) that we are referring them without question to that species. The lateral costae

of our forms do not reach the basal cusp margin, but the types exhibit some variation in this respect, also, hence we attribute little importance to this fact.

Occurrence.—McMicken member, Eden formation, locality 13096.

Type.—Figured hypotype, OSU 22165.

PANDERODUS STRIATUS (Stauffer)
Pl. 131, fig. 4

Paltodus striatus STAUFFER, 1935b, Jour. Paleontology, v. 9, p. 613, pl. 74, figs. 3,16; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art 3, p. 144; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 729, pl. 5, fig. 6.

Simple, asymmetrical, recurved cones, somewhat compressed and deeply excavated. Anterior margin acutely rounded; one antero-lateral face essentially flat, the other slightly concave. Flattened antero-lateral face sharply offset at its posterior edge to form a distinct longitudinal costa, followed posteriorly by broadly convex zone. Convex antero-lateral face followed posteriorly by broadly rounded longitudinal rib; posterior half of same face flat or very slightly convex. Posterior margin blade-like. Excavation conical, compressed; apex near anterior margin at point of maximum recurvature of element.

Occurrence.—Very rare in both Fulton-Economy and Southgate members at localities 13095, and 13100.

Types.—Figured hypotype, OSU 21421; unfigured hypotype, OSU 22146.

PANDERODUS UNICOSTATUS
(Branson & Mehl)
Pl. 131, fig. 3

Paltodus unicostatus BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 42, pl. 3, fig. 3; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 144; RHODES, 1953, Phil. Trans. Roy. Soc. London, ser. B, no. 647, p. 298, pl. 21, figs. 84–88, pl. 22, figs. 155,156; p 23, fig. 214–216; RHODES, 1955, Quart. Jour. Geol. Soc. London, v. 111, p. 127, pl. 10, figs. 1,3.

Paltodus? unicostatus GLENISTER, 1957, Jour. Paleontology, v. 31, p. 729, pl. 85, fig. 1.

Panderodus unicostatus ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 284.

We have one specimen that appears to belong in the type species of *Panderodus*. It is a somewhat recurved, compressed simple cone with a narrowly rounded anterior margin, one smooth, gently convex face, and a blade-like posterior edge. The outer antero-lateral corner is marked by a sharp offset, producing a distinct longitudinal costa. The base is deeply excavated by a conical cavity, the tip of which is anterior in position and located slightly proximad of the point of maximum recurvature.

Occurrence.—Rare in Southgate member, Eden formation, locality 13107.

Type.—Figured hypotype, OSU 22148.

Genus PHRAGMODUS Branson & Mehl, 1933
Type species: *Phragmodus primus*
Branson & Mehl, 1933

Asymmetrical, paired conodont-elements, with bi-, and in some cases tri-costate cusps succeeded posteriorly by an arched bar, at the crest of which there is a denticle that rivals or exceeds the cusp in size but does not surmount an expansion of the basal excavation. Cusp and major posterior denticle separated in most species by one or more minor denticles that tend to be overgrown by and therefore included in the major posterior denticle as the element enlarges. Major posterior denticle followed by a variously developed posterior bar, the upper surface of which bears denticles of minor size. Under side of element excavated; basal excavation of cusp a relatively deep conical cavity, the tip of which is deflected toward the convex anterior margin of the cusp.

Remarks.—Conodont-elements referred by American writers to *Phragmodus* are distinctive and are apparently restricted in their occurrence to Middle and early Upper Ordovician rocks of the North American midcontinent province. They are similar in many respects to Anglo-Scandinavian and Appalachian conodont-elements that belong in *Periodon* Hadding and early in our study of Eden conodonts, we were inclined to agree with Lindström (1955) that the two genera are synonymous. However, even if such species as *Periodon serra* (Hadding) are excluded from *Periodon* (as Dr. Lindström agrees they should be) such a variety of similar things has been included in *P. aculeatus* Hadding, the type of *Periodon*, that we hesitate to combine the two groups. Both *Periodon* and *Phragmodus* are more or less arched, bar-, or blade-like genera; in

both a denticle of superior size surmounts the crest of the posterior arch, and, in both, the cusp tends to be bi-, or tri-costate. In *Periodon*, the basal cavity is "inverted" posteriorly, but this phenomenon is not uncommon in the evolutionary development of most bar- and blade-like genera so we cannot accord it generic significance. However, there is a definite tendency in *Periodon aculeatus* for the laterally deflexed anterior costa to be rather conspicuously denticulated and, in a number of presumably typical forms that Dr. Lindström sent us from the Schroeteri limestone of Öland, Sweden, a minutely denticulate lateral costa is also developed on the side opposite that toward which the anterior costa is deflected. Conodont-elements like the latter are not at all uncommon in an undescribed collection we have from the Pratt Ferry formation of Alabama, and, until *Periodon aculeatus* is revised or limited, they would certainly belong in it. Consequently, even though we are favorably disposed toward combining *Phragmodus* and *Periodon*, we feel that it would be unwise to do so until we know more about the range of permissible variation in the type species of the latter genus. Only in late species of *Phragmodus*, apparently, is there conspicuous cusp costation; in none of these species are the costae denticulate.

In Europe, *Periodon* is known from a number of localities. Lindström (1955) records it in the Schroeteri limestone of Öland and in strata of the zone of *Climacograptus haddingi* in Scania. *Periodon* is also known (Lindström, 1957) from the *Climacograptus wilsoni* zone at Morroch Bay, Scotland, and, in a recent paper (Lamont & Lindström, 1957) the presence of *Periodon* is noted in Llandeilan rocks at a number of places in the southern uplands of Scotland. Ethington, Furnish, & Markewicz (1958) indicate the presence of conodont-elements strikingly similar to *Periodon aculeatus* Hadding in a "Martinsburg" exposure in New Jersey, and an undescribed fauna from Pratt Ferry, Alabama, contains representatives of this species, as it is now interpreted, in some abundance.

Phragmodus appears for the first time in the Marmorian McLish formation of Oklahoma (Branson & Mehl, 1943), but does not become an important or particularly well represented member of Ordovician conodont faunas until late in the Wilderness (Zell member of Plattin, Missouri; Decorah shale of Iowa and Minnesota). In Trentonian and early Cincinnatian (Edenian and Maysvillian) strata, *Phragmodus* is easily the most abundant conodont genus. In our Eden collections, for example, at least 40% of the specimens recovered belong in *Phragmodus*. No representatives of the genus have yet been described from rocks of late Upper Ordovician (Richmondian) age, but Branson, Mehl, & Branson (1951) report that *Phragmodus* occurs in the Arnheim formation, generally considered now to be the introductory deposit of the Richmond group in its type area.

The known distribution and stratigraphic ranges of *Periodon* and *Phragmodus* suggest that *Phragmodus* appeared first (in the Marmor) and that its development was restricted to the North American midcontinent province. *Periodon*, on the other hand, is not yet known from rocks older than the Schroeteri limestone (zone of *Climacograptus haddingi*)—probably Ashby—and representatives of the genus are not known to occur in rocks of Upper Ordovician age in Europe or elsewhere. *Periodon* is apparently restricted, then, to Middle Ordovician rocks deposited in the Anglo-Scandinavian and Appalachian provinces. The fact that the two groups developed independently may, at least for the present, justify retaining them in separate genera—even though they are probably closely related and may represent only provincial variants of the same general type of conodont-elements.

PHRAGMODUS UNDATUS Branson & Mahl
Pl. 133, figs. 7,10,13

Phragmodus undatus BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 115,116, pl. 8, figs. 22–26; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 146; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 733, pl. 88, figs. 1,2; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 285,286, pl. 41, fig. 12.

We are referring all of our Eden *Phragmodus* to this species, even though it is possible to recognize within this large group of specimens at least three distinct groups. All of our specimens are alike, however, in that they are compressed and consist of a costate, basally proclined but distally erect or

slightly reclined cusp that is continuous posteriorly with an arched, excavated, more or less sinuous bar, surmounted, at the apex of the arch, by a laterally compressed, slightly reclined denticle that is generally somewhat stouter and longer than the cusp itself. The cusp and major posterior denticle are separated by two, three, or four minor denticles, the number tending to be less in larger specimens, in which the most posterior of these denticles becomes overgrown by the anterior margin of the major posterior denticle. The posterior portion of the posterior process, or bar, is sinuous (as is the anterior part of the element) and exhibits a rather regular "hindeodelloid" denticulation. In most of our specimens, this fragile structure has been broken from the element immediately posterior to the major posterior denticle; however, in most specimens enough of the bar remains so that it is possible to demonstrate that the curved or sinuous fragments found in the same samples (and referred by Stauffer and others to *Pravognathus*) belong in this species. The under surface of the element is rather deeply excavated; beneath the cusp, this excavation is represented by a deep, compressed, conical cavity, the apex of which is deflected anteriorly and lies near the anterior cusp margin. The excavation is continued beneath the posterior process and it becomes shallower and narrower posteriorly.

Remarks.—A great deal of variation in sinuosity and development of the posterior process exists in specimens available to us, but we feel that little importance can be attached to this. Ornamentation of the cusp, however, is not so variable, and three distinct groups of *Phragmodus undatus*, represented by about equal numbers of specimens in our collections, can be recognized on this basis. These should perhaps be described as named species or subspecies, but we are at present skeptical as to the value of any such procedure. In one group, the cusp is bicostate; the posterior costa, which is only weakly developed, is continuous with the denticles of the posterior series, whereas the anterior costa curves laterally so as to occupy the antero-lateral corner of the cusp in cross section. A second group is similar to the first, but a third costa is developed at about mid-width on the face opposed to the one toward which the anterior costa is deflected. In a third group, both sides of the cusp bear longitudinal costae, in addition to the deflected anterior and weakly developed posterior costae. Members of the last-named group also seem to be somewhat more consistently sinuous than are those of either the first or second groups described. The three patterns of ornamentation just described appear to characterize groups of *Phragmodus undatus* at all stages of their development, and there is little, if any, gradation between the groups. A similar series of variations has been noted by Glenister (1957) in material collected from the Maquoketa formation of Iowa, and by Ethington (1959) in collections from the Galena formation of Iowa.

Occurrence.—Forty percent of our Fulton-Economy conodonts, 19% of our Southgate specimens, and 30% of the conodonts collected from the McMicken member of the Eden belong in *Phragmodus undatus*. Representatives of the species are abundant at every horizon in every section sampled.

Types.—Figured hypotypes, OSU 21448, 22192; unfigured hypotypes, OSU 21443–21447, 21449–21451, 21457–21459, 22149–22153, 22188, 22189–22191, 22193.

Genus PRIONIODINA Ulrich & Bassler, 1926
Type species: *Prioniodina subcurvata* Ulrich & Bassler, 1926

Compound, individually asymmetrical, arched, blade-like conodont-elements with a relatively large, erect or distally reclined cusp and anterior and posterior processes that bear discrete denticles and are continuous with more or less well defined anterior and posterior costae on the cusp. Under cusp surface deeply sheathed in early species; sheath inverted and basal cavity less well defined (except beneath cusp) in later species.

Remarks.—*Prioniodina*, *Euprioniodina*, *Ligonodina*, *Eoligonodina*, *Lonchodina*, and *Ozarkodina* are all based on species that are, in themselves, easily distinct as species. However, the genera founded on these species are difficult to distinguish formally and there has been a considerable difference of opinion as to what should or should not be included in each of them. The relative size of the cusp, the length and inclination of

the processes, the absence or presence of a well defined basal excavation, and the tendency for the denticles to be confluent or discrete (as well as for the unit to be arched or straight) seem to be highly variable morphological properties and we suspect that any one of them used alone is an insufficient criterion for generic distinction.

A majority of the forms previously referred to *Prioniodina* are rather prominently arched forms characterized by anterior and posterior processes that lie in virtually the same plane as the cusp. This is also true of many species referred to *Ozarkodina*. *Ligonodina* includes forms in which the anterior process, continuous with a sharply defined anterior costa on the cusp, is directed laterally, downward, and posteriorly at its distal end; *Eoligonodina* includes forms with a sheathed basal cavity, whereas the attachment edges of *Ligonodina* are inverted. *Lonchodina*, as its authors state (Ulrich & Bassler, 1926) is like *Euprioniodina* (and *Ligonodina*)—that is, it includes conodont-elements with denticulate anterior and posterior processes, the anterior process being directed downward and toward the posterior. However, the unit is bowed as well as arched, the denticles are more frequently discrete, and the cusp in many cases is not readily distinguishable from the denticles.

All the specimens we are referring to *Prioniodina* are bowed and highly arched, and the process denticles are discrete and peg-like, even though they may be somewhat compressed laterally. Furthermore, in all these forms, the cusp is of superior size. These properties (prominent arch, large cusp, discrete denticles) taken together, provide a reasonable way of distinguishing *Prioniodina* and *Ozarkodina*, and *Prioniodina* and *Ligonodina*, *Eoligonodina*, and *Lonchodina*. No one of our specimens is as distinctly and acutely arched as the type of *Euprioniodina* and, at least for the present, the form of the arch may be considered to distinguish the two genera.

PRIONIODINA DELECTA (Stauffer)
Pl. 131, fig. 11

Ozarkodina delecta STAUFFER, 1935a, Geol. Soc. America, Bull., v. 46, p. 148,159, pl. 10, fig. 40; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 137; GLENISTER, 1957, Jour. Paleontology, v. 31, p. 735, pl. 88, figs. 8,9; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 283,284, pl. 41, fig. 17.

?Ozarkodina macrodentata ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 284, pl. 41, fig. 14.

Remarks.—This species has a cusp that is markedly larger than any of the process denticles and may be distinguished from *Prioniodina oregonia* Branson, Mehl, & Branson by the fact that the denticles tend to be laterally compressed on both limbs rather than subcircular or subelliptical in cross section on only the posterior limb. In *P. rotunda*, n. sp., the cusp and the denticles on both limbs are stout and subcircular in cross section.

Prioniodina macrodentata is a very distinctive form first described from the Fort Peña formation of the Marathon Basin, Texas by Graves & Ellison (1941). The types are fragmentary and are indeed similar to *P. delecta*, as Ethington (1959) notes. However, complete representatives of this species in undescribed collections from the Pratt Ferry formation of Alabama show it to be clearly distinct from *P. delecta* and markedly different from the Galena specimens Ethington referred to it. That is, the specimens at hand are very strongly bowed, have an exceedingly wide, prominently carinate cusp, markedly swollen processes, and a subapical cavity far less commodious and more "navel-like" than the one figured by Ethington. For these reasons, we suspect that Ethington's *Ozarkodina macrodentata* is a variant of *Prioniodina delecta*, also present in the Galena, or represents a new species.

Occurrence.—Rare in the McMicken member, Eden formation, at locality 13107.

Type.—Figured hypotype, OSU 22229.

PRIONIODINA OREGONIA Branson, Mehl, & Branson
Pl. 132, fig. 18; Pl. 133, fig. 9

Prioniodina oregonia BRANSON, MEHL, & BRANSON, 1951, Jour. Paleontology, v. 25, p. 15, pl. 3, fig. 18; pl. 4, figs. 28–32.

Remarks.—Our Eden specimens are closely similar to the ones figured by Branson, Mehl, & Branson, hence we are referring them to *Prioniodina oregonia* without question. The limbs of the few complete individuals in our collections are subequal and the denticles tend to be somewhat len-

ticular (rather than subcircular) in cross section. However, both these features seem to be somewhat variable and we do not think any specific value should be attached to them.

Occurrence.—Abundant in Fulton-Economy, Southgate, and McMicken members, Eden formation. At least one specimen was recovered from nearly every sample searched for conodonts.

Types.—Figured hypotypes, OSU 21480, 21481; unfigured hypotypes, OSU 22154, 22230, 22231.

PRIONIODINA ROTUNDA, n. sp.
Pl. 131, fig. 12; Pl. 133, fig. 8

Diagnosis.—A robust, massive *Prioniodina* with thick processes, subquadrate cusp, widely spaced, discrete denticles that are subcircular in cross section, and a pronounced inward flare of sheath beneath cusp.

Description.—Unit arched and slightly bowed, limbs forming an angle of about 110 degrees with each other. Cusp long, subquadrate in cross section, costate anteriorly and posteriorly with sharply convex lateral faces; recurved posteriorly and twisted somewhat inwardly. Anterior process thick, straight, bearing two or more stout, widely spaced, posteriorly directed denticles that are ovate in cross section. Posterior bar of unknown length, bearing denticles like those of anterior process but smaller and almost perpendicular to base. Excavation wide, deep, and subconical beneath cusp, becoming shallow and tapering in width toward termini of processes.

Remarks.—The massive form of this species, together with the subquadrate cross section of the cusp serve to distinguish it from previously described species of *Prioniodina*. The species becomes much more abundant in the superjacent Fairview formation.

Occurrence.—Rare in the McMicken member of the Eden at localities 13104, 13105, 13108.

Genus PRIONIODUS Pander, 1856
Type species: *Prioniodus elegans* Pander, 1856

Pander's diagnosis of this genus was very broad and the conodont-elements he referred to it are certainly not all congeneric. In addition, it appears (Öpik, 1936; Branson & Mehl, 1944; Lindström, 1954) that Pander's diagnosis was based upon fragmentary material and the concept of *Prioniodus* that resulted from later interpretations of this material is in error. Öpik, Branson & Mehl, Lindström, and Rhodes & Müller (1956) have all pointed out that topotype representatives of *Prioniodus elegans* Pander have three denticulate processes (anterior, posterior, and inner lateral) arising from the base of a subcentral cusp, rather than the two processes (anterior and posterior) that have been thought by many authors to be typical of the genus. A majority of the many species that have been referred to *Prioniodus* have only two processes, one of which (the anterior) may or may not be denticulated; clearly, these species do not belong in *Prioniodus*. Rhodes & Müller (1956) have, therefore, removed the bulk of such species to their genus, *Neoprioniodus*, leaving in *Prioniodus* only those compound conodont-elements with a " . . . subcentral cusp, from the base of which diverge three denticulate edges or processes, one posteriorly, one anteriorly, and one laterally" (Lindström, 1954).

As thus restricted, *Prioniodus* is probably confined to the Ordovician. Representatives of the genus appear to be most common in Lower and Middle Ordovician rocks; we have only one specimen, which probably belongs in a new species, from the Eden of Ohio and no similar forms have yet been recorded from presumably equivalent or younger strata.

PRIONIODUS, n. sp.
Pl. 132, fig. 8

We have a single *Prioniodus* from the Fulton-Economy that is clearly distinct from previously figured representatives of the genus and almost certainly belongs in an undescribed species. However, we are reluctant to base a new species on just a single specimen, for there is no way to evaluate its position in a probably somewhat variable group.

The specimen to which we refer is a *Prioniodus* with a long, tapering, denticulated anterior process that forms a direct continuation of the anterior margin of the laterally compressed cusp; a short, straight

posterior process, continuous with the keel-like posterior margin of the cusp; and a short, blade-like lateral process in a plane perpendicular to that defined by the cusp and posterior process. Cusp erect proximally, slightly recurved distally, laterally compressed, and rather prominently keeled both anteriorly and posteriorly. Its sides are marked by a series of closely spaced longitudinal striae. The anterior process, which is the longest of the three processes, is produced almost directly downward from the cusp and is bowed gracefully outward distally. Its under surface is excavated for its entire length and its upper surface bears some seven or eight laterally compressed, basally fused but distally discrete, sharp-pointed denticles, all of which point anteriorly and are contained in the curving plane defined by the process. The posterior process is rather deeply excavated basally and bears four or five low, laterally compressed, sharp-pointed denticles on its upper surface. The inner lateral process is short, antero-posteriorly compressed, excavated, and bears three low, sharp-pointed, basally confluent denticles on its upper surface. It arises from a point near the base of the anterior margin of the cusp and does not appear to be prolonged onto the side of the cusp as a carina, costa, or ridge. The basal excavation of the entire unit is determined by those of the three processes, which meet beneath the cusp to form a rather deep, conical cavity.

Occurrence.—Fulton-Economy member, Eden formation, locality 13100.

Type.—Figured specimen, OSU 21470.

Genus SAGITTODONTUS Rhodes, 1953
Type species: *Sagittodontus robustus* Rhodes, 1953

Barb-like, asymmetrical, incipiently compound conodont-elements consisting primarily of a stout, recurved cusp that is carinate laterally and posteriorly. At least one of these carinae may be minutely denticulated or crenulated.

Remarks.—Lindström (1954) expresses the conviction that *Sagittodontus* is probably a synonym of *Acodus* Pander, a genus of simple, asymmetrical, unicostate conodont-elements. The presence of three costae or "sharp dividing edges" (Rhodes, 1953) seems to us to preclude reference of *Sagittodontus* to *Acodus*, as does the tendency for one costa to develop minute denticles in *Sagittodontus*. The type species is from the upper Caradocian Gelli-grin limestone of Wales and it has also been reported (Rhodes, 1955) from the Pen-y-garnedd limestone of Wales, which is probably equivalent in age to the Gelli-grin. An additional species, *S. gracilis*, is described by Sannemann (1955) from two localities in the Randschiefer series of Bavaria, which is probably of early Middle Ordovician age (Llanvirn-Llandeilo, or slightly older). Comparable forms have recently been described by Ethington (1959) from the Galena formation of Iowa.

SAGITTODONTUS DENTATUS Ethington
Pl. 131, figs. 7,8

Sagittodontus dentatus ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 287, pl. 39, fig. 13.

Erect to slightly recurved, subconical, individually asymmetrical conodont-elements. Each unit is subtriangular in transverse section, consisting of a stout, blunt cusp, the sides of which are divided into three distinct longitudinal segments by well developed lateral and posterior carinae. Distally, the anterior cusp margin is broadly rounded; proximally, this same side is concave and continuous with a broad, spatulate, somewhat asymmetrical emargination in the basal border of the sheath. Lateral segments of unit convex distally, concave inward proximally, and, like anterior margin, continuous basally with slight, apically produced emarginations in the sheath border. Inner lateral carina blade-like in several of our specimens and exhibits a distinct crenulation, or a more or less well developed denticulation, through much of its length. Denticles, when developed, low, blunt, laterally compressed structures, confluent with adjacent denticles for most of their length. Basal excavation deep, compressed subconical concavity, the apex of which is bluntly rounded, rather than pointed, and lies directly beneath cusp tip.

Remarks.—*Sagittodontus dentatus* and *S. robusta* are very much alike and appear to differ primarily in that one lateral process bears minute denticles in the former, whereas Rhodes (1953) notes only " . . . irregular indentations along one of the edges"

in the latter. We suspect that this is a somewhat variable character and perhaps of little taxonomic significance.

Occurrence.—Fulton-Economy and McMicken members, Eden formation, at localities 13095, 13105.

Types.—Figured hypotype, OSU 22194; unfigured hypotypes, OSU 21487, 22195, 22207.

Genus SCOLOPODUS Pander, 1856
Type species: *Scolopodus sublaevis* Pander, 1856

Pander's diagnosis of this genus reads as follows:

> "Schlanke, verschieden gestaltete Zähne, mit abgerundeten vorderen und hinteren Kanten und convexen mehr oder weniger gerippten Oberflächen. Sie unterscheiden sich gleich beim ersten Anblick durch ihre festere Substanz, weisse Farbe und Mangel der Kiele von der vorher beschriebenen."

Lindström (1954) points out that neither the white color nor the hardness of the elements provide diagnostic generic characters and the rounded anterior and posterior margins and numerous costae are found also in *Paltodus*. The types of *Paltodus* and *Scolopodus* differ, however, in that the costae of the former are asymmetrically disposed whereas those of *Scolopodus sublaevis* appear to be equally developed and symmetrically arranged on both sides. Hence, it seems that only bilaterally symmetrical, multicostate simple cones can be referred to this genus, whether or not the anterior and posterior margins are round or sharp.

Representatives of *Scolopodus* are numerous in rocks of Lower Ordovician age and a few have been reported from both Middle and Upper Ordovician strata. No post-Ordovician species appear to have been described.

SCOLOPODUS INSCULPTUS (Branson & Mehl)
Pl. 130, fig. 6

Phragmodus insculptus BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 124, pl. 10, figs. 32–34; GRAVES & ELLISON, 1941, Missouri Univ. School Mines & Metallurgy, Bull., Tech. Ser., v. 14, p. 6, pl. 3, fig. 1; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 146; RHODES, 1953, Phil. Trans. Roy. Soc. London, ser. B, no. 647, p. 310, pl. 21, figs. 136,153,154; RHODES, 1955, Quart. Jour. Geol. Soc. London, v. 111, p. 136, pl. 10, fig. 17.

Distacodus insculptus ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 275,276, pl. 39, fig. 10.

Remarks.—Two specimens from the Fulton-Economy agree so closely with conodont-elements from other localities referred to this species that we have placed them in it with no question. Branson & Mehl mention the existence of additional denticles posterior to the principal cusp, but they do not figure such a specimen and no complete form has yet been illustrated. We suspect that similarly costate forms like *Phragmodus undatus* could be mistaken for the type of element represented by *Scolopodus insculptus*, if they were broken or otherwise incomplete or atypically developed.

This species seems to be typical of Anglo-Scandinavian and Appalachian conodont faunas. It is well represented in our undescribed collection from the Pratt Ferry formation of Alabama, which contains, in addition to this species, a great many conodont-elements known best from or restricted in their development to the North European Ordovician.

Occurrence.—Rare near top of Fulton-Economy member, locality 13095.

Types.—Figured hypotype, OSU 21420; unfigured hypotype, OSU 21422.

Genus TRICHONODELLA Branson & Mehl, 1948
Type species: *Trichognathus prima* Branson & Mehl, 1933

Trichonodella includes unpaired, compound, symmetrical or very slightly subsymmetrical conodont-elements consisting of an erect or recurved cusp, denticulate lateral processes of essentially equal development, and, in many species, a more or less distinct, for the most part non-denticulate extension or expansion of the proximal posterior margin of the cusp. The base is deeply excavated beneath the cusp, the lateral processes, and the posterior extension or expansion of the cusp base.

Remarks.—*Trichonodella* is clearly related to *Hibbardella* and *Roundya*, differing primarily from the former in that the basal excavation is continued beneath the lateral processes rather than being confined to a shallow pit beneath the cusp itself. In *Roundya*, the posterior extension or expansion of the base is produced into a distinct,

denticulated, bar-like process, surmounted by large, discrete denticles; furthermore, the basal excavation seems to be largely "inverted" beneath the lateral processes, as in *Hibbardella*. Other closely related forms, probably representing an elaboration of the *Roundya-Trichonodella-Hibbardella* stock in the Devonian, are *Diplododella*, *Ellisonia*, *Elsonella*, and *Tripodellus*.

Hass (1953) would apparently like to distinguish between *Trichonodella* and *Roundya* on the basis of the presence of posterior denticles in the latter and their absence in the former. We believe that this is overly artificial. *Roundya* is certainly distinct from *Trichonodella* in many ways, as indicated above, and we feel that more attention should be paid to a combination of differences than to the presence or absence of a few denticles on the posterior process. That is, *Roundya*, in typical form, is certainly more advanced in that its basal cavity is limited by "inversion" on the limbs and the posterior margin of the cusp is produced into a conspicuous, discretely denticulated process. All of the Ordovician forms with which we are familiar have distinct and ordinarily capacious extensions of the basal excavation beneath the lateral processes; most of them have laterally compressed, somewhat confluent denticles; and none of them develops the greatly enlarged posterior bar that seems characteristic of *Roundya*. Consequently, even though our Ordovician specimens may have one or two low denticles posterior to the cusp, we are referring them to *Trichonodella*, for we interpret this phenomenon to be of minor significance taken alone.

TRICHONODELLA ANGULATA, n. sp.
Pl. 131, figs. 9,13

Diagnosis.—A *Trichonodella* with a short, non-denticulated posterior expansion, slightly twisted cusp, subquadrate in cross section proximally, subelliptical distally, with two distinct antero-lateral costae continuous with denticles of lateral series and two posterior costae, one of which is rounded and indistinct, the other angular and always distinct. Posterior process short, upturned, with sharp, laterally deflected upper edge.

Description.—Delicate to rather massive compound conodont-elements with a slightly recurved cusp that is subquadrate in proximal cross section. Anterior face of cusp slightly convex transversely, with sharp antero-lateral edges that converge distally and define a plane somewhat oblique to that containing the anterior side of the cusp and lateral processes. Cusp sides flat or somewhat concave longitudinally; one postero-lateral edge broadly rounded, the other longitudinally costate. The rounded postero-lateral edge disappears and the costate postero-lateral edge twists toward the posterior margin of the cusp distad so that at cusp mid-height the cross section is lens-shaped with sharp anterior and posterior edges. Antero-lateral costae continuous basally and laterally with denticulated upper surface of lateral processes. These processes are of about equal development, enclose between them an angle of from 60–90 degrees, have rather shallow, distally tapering extensions of the basal excavation on their under sides, and bear a series of at least three discrete, sharp-pointed, antero-posteriorly compressed denticles on their upper surfaces. Basal portion of twisted posterior (or postero-lateral) costa continuous with short, rather sharply upturned, laterally deflected posterior expansion of cusp base. Viewed from the posterior, this lateral deflection gives the entire unit a somewhat asymmetrical appearance. Subapical excavation deep, subconical, continuous with extensions beneath lateral and posterior processes.

Remarks.—These conodont-elements are strikingly similar to *Trichonodella flexa* Rhodes (1953) and we suspect that the Galena forms referred to *T. flexa* (Ethington, 1959) belong in *T. angulata*, which is distinguished from *T. flexa* by the fact that the posterior process is laterally deflected and the basal portion of the lateral processes is not twisted so as to face posteriorly.

Occurrence.—Not uncommon in Fulton-Economy, Southgate, and McMicken members of the Eden. Abundant in superjacent Fairview formation.

Types.—Holotype, OSU 22198; unfigured paratypes, OSU 21476, 22156, 22196, 22197. In addition, two specimens, OSU 22199, 22200, are referred tentatively to this species.

TRICHONODELLA SUBUNDULATA, n. sp.
Pl. 131, figs. 2,5,10

Diagnosis—A species of *Trichonodella* with a prominent, recurved cusp that is longitudinally costate posteriorly, compressed distally, subquadrate proximally, and longitudinally grooved basally near its junction with a transversely rounded posterior process of unknown length.

Description.—Cusp large, long, slightly recurved distally; circular to slightly subquadrate in cross section proximally with prominent antero-lateral costae and a relatively deep, longitudinal groove posteriorly. Distally, the cusp is subcircular to elliptical in cross section, with sharp, well defined anterior and posterior costae. Posterior costa continued basally so as to subdivide basal posterior groove. Lateral processes continuous with lateral extension of antero-lateral cusp costae. Processes enclose between them an angle of 60–80 degrees, are compressed, rather deeply excavated, and bear a series of short, discrete, moderately spaced denticles that are slightly compressed antero-posteriorly. Denticles tend to crowd slightly in front of cusp. Basal excavation deep beneath cusp, continuous with shallower, distally tapering cavities beneath lateral processes, and flaring posteriorly beneath upturned process of unknown length.

Remarks.—This new species is closely allied to *Trichonodella undulata* Branson, Mehl, & Branson, as the name suggests. It is thought to differ from *T. undulata* primarily in the absence of peg-like denticles on the upper surface of the posterior process. It should perhaps be noted that a grooved or channeled posterior cusp margin is also characteristic of *Roundya* and the conodont-elements now included in *T. subundulata* and *T. undulata* may well be very closely related to typical *Roundya*.

Occurrence.—Rare in Fulton-Economy, Southgate, and McMicken members at localities 13100, 13103, 13105–13108.

Types.—Cotypes, OSU 21477, 22155; unfigured paratypes, OSU 22201–22203.

TRICHONODELLA TENUIS (Branson & Mehl)
Pl. 132, figs. 10,15

Trichognathus tenuis BRANSON & MEHL, 1933, Missouri Univ. Studies, v. 8, p. 131, pl. 10, figs. 18; GRAVES & ELLISON, 1941, Missouri Univ. School Mines & Metallurgy, Bull. Tech. Ser., v. 14, p. 6,7, pl. 3, fig. 28; BRANSON, 1944, Missouri Univ. Studies, v. 19, p. 98; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 199.

Remarks.—The few specimens of this species in our collections compare closely with the specimen figured by Branson & Mehl, hence there is little doubt as to their identification. The species is characterized by the prominently compressed cusp, set far behind the thin, delicate lateral processes

Occurrence.—Rare in the McMicken member of the Eden at localities 13100, 13104–13107.

Types.—Figured hypotype, OSU 22204; unfigured hypotype, OSU 2205.

Genus ZYGOGNATHUS Branson, Mehl, & Branson, 1951
Type species: *Zygognathus pyramidalis* Branson, Mehl, & Branson, 1951

Paired, individually asymmetrical conodont-elements with prominent cusp and denticulated lateral processes that are continuous with lateral cusp costae. Outer lateral process curves posteriorly and can be confused with a posterior process. However, in typical specimens, outer lateral process is separated from undenticulated, somewhat flaring posterior margin of cusp base by a narrow, shallow, trough-like depression. Inner lateral process generally short and, in most specimens, included in curved surface defined by anterior cusp margin. Base deeply excavated beneath cusp and processes.

Remarks.—Orientation of these perplexing conodont-elements has caused us considerable difficulty. Branson, Mehl, & Branson (1951) seem to have experienced similar problems. An examination of the specimens available to us indicates that the cusp carinae, with which the denticulate processes are continuous basally, are lateral, rather than anterior and posterior, in position. These elements remind us more of a deformed *Trichonodella* than of *Ptiloconus* or *Eoligonodina* with which they were compared by Branson, Mehl, & Branson. That is, if the posterior process of *Trichonodella* were somewhat skewed (as in *T. angulata*,

n. sp.) a unit similar to *Zygognathus* would result.

The type species of *Zygognathus* is from the Richmond group of Kentucky and Indiana. An examination of the types of Stauffer's (1935a) *Trichognathus deformis* and *T. illustris* from the Glenwood shale of Minnesota indicates, however, that these species belong in *Zygognathus* rather than in *Trichonodella*. Furthermore, one of the somewhat asymmetrical Glenwood forms that Stauffer, (1935a) referred to *Trichognathus recurva* Branson & Mehl does not belong in *T. recurva* as we interpret that species but seems to represent an early species of *Zygognathus*.

Rhodes (1953) and Ethington (1959) have referred to *Gyrognathus* two conodont species, *G. elongata* and *G? superba*, which appear to be like those we are referring to *Zygognathus deformis* (Stauffer). These species do not belong in *Gyrognathus*, which is unquestionably a junior subjective synonym of *Oulodus* Branson & Mehl, as Ellison (1946) pointed out and as our examination of the types of *G. prima* Stauffer indicates. Professor Rhodes has examined some of the specimens we are referring to *Zygognathus* and writes us that they are similar, if not precisely identical to the forms he described as *Gyrognathus elongata*, hence we are reasonably certain that the two are the same. Professor M. G. Mehl has also confirmed our suspicion that these specimens belong in *Zygognathus*. Furthermore, there is no objective way to separate *G. elongata* Rhodes and *Trichognathus deformis* Stauffer, both of which seem to have, in addition to comparable form, a similar stratigraphic range.

Insofar as we can determine, *Zygognathus* first appears in rocks of Middle Ordovician age (Glenwood shale and its equivalents) and is present in European and American conodont faunas more or less consistently until the end of the Ordovician.

ZYGOGNATHUS DEFORMIS (Stauffer)
Pl. 132, figs. 1,5

Trichognathus deformis STAUFFER, 1935a, Geol. Soc. America, Bull., v. 46, p. 155–156, pl. 12, fig. 23; STAUFFER, 1935b, Jour. Paleontology, v. 9, p. 619, pl. 71, fig. 46; FAY, 1952, Univ. Kansas Paleont. Contr., Vertebrata, art. 3, p. 198; SWEET, 1955, Jour. Paleontology, v. 29, p. 257, pl. 29, fig. 6.

Gyrognathus elongata RHODES, 1953, Phil. Trans. Roy. Soc. London, ser. B, no. 647, p. 318–319, pl. 22, figs. 201,202,205,206; ETHINGTON, 1959, Jour. Paleontology, v. 33, p. 279, pl. 40, fig. 13.

Cusp stout, erect to slightly proclined, subcircular to compressed in transverse section and marked laterally by more or less distinct, sharp-edged longitudinal costae. Costa on outer side of cusp produced downward, outward, and posteriorly as a bowed, laterally compressed, denticulated process, subparallel with the smoothly rounded, nondenticulate posterior margin of the cusp, but separated from it by a shallow, longitudinal furrow. Outer lateral process incomplete in all specimens at hand, but it apparently extended originally for a considerable distance beyond the posterior margin of the cusp base. The upper surface of this process is set with six or more relatively short, spatulate denticles, subelliptical in transverse section, discrete above the basal portion of the process, and directed upward and outward distally. Costa on inner side of cusp closely approximated to anterior margin and continuous at cusp base with a short, compressed, downwardly directed, denticulated process, confined, essentially, to the curving surface defined by the anterior margin of the cusp. Upper surface of inner lateral process bears two or three compressed, sharp-pointed denticles, the innermost of which is laterally confluent with, or only slightly separated from the cusp and of equal or somewhat greater length. The posterior portion of the cusp flares slightly and the thin-walled sheath thus formed encloses a deep, subconical basal cavity, extensions ofwhich occur as narrow, longitudinal troughs beneath the lateral processes.

Remarks.—This species is distinguished from other species of *Zygognathus* by the fact that the innermost denticle of the inner lateral process is of a size equivalent to the cusp itself. In addition, the denticles are compressed rather than peg-like, a condition that obtains in the type species.

Occurrence.—Common in Fulton-Economy, Southgate, and McMicken members of the Eden formation. About one percent of our Fulton-Economy and Southgate conodonts belong in this species, whereas some 4.6% of those collected from the McMicken are referable to *Zygoghathus deformis*. Repre-

sentatives of this species were found at every locality sampled, and in nearly every sample

Types.—Figured hypotypes, OSU 22157, 22217; unfigured hypotypes, OSU 21479, 22159, 22218–22221.

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BIBLIOGRAPHY AND INDEX TO NEW GENERA, SPECIES, AND VARIETIES OF FORAMINIFERA FOR THE YEAR 1956

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ABSTRACT—The following Bibliography lists a total of 632 papers dealing exclusively or partly with Foraminifera published during the year 1956. Supplements of titles referring to previous years are at present in preparation and will shortly be published. The steady increase of publications in which fossil and recent Foraminifera are described, or only mentioned, makes it more and more difficult for the compiler single-handedly to cover the field in such a way that the annual bibliographies become reasonably complete. Such a goal can be achieved only with the active cooperation of the authors by forwarding their reprints automatically and without personal request to the compiler.

The Index for the year 1956 cites as new foraminiferal taxa: 1 suborder, 9 families, 5 subfamilies, 68 genera, 2 subgenera, 729 species, 111 varieties and subspecies, 10 nomina nova, 43 homonyma, 1 forma nova and 1 nomen nudum. Forms to which the open nomenclature was applied are not, and will not be, listed in this and forthcoming bibliographies and supplements.

The compiler is fully aware of the fact that there are more new foraminiferal taxa erected in 1956 than actually listed here in spite of every effort made for complete coverage. Publications recorded in the Bibliography under Nr. 141, 307, 308, 383, 384, 391, 531, and possibly others which had not been accessible or available contain about 150 new taxa not listed in the Index for 1956. Information regarding such omissions will be highly appreciated.

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—— —— —— var. *carinata* Khalilov, **306,** p. 212, pl. 4, fig. 13. Lower Oligocene, Azer-

baidzhan area, USSR. (Note: Preoccupied by *Bolivina beyrichi carinata* Hantken, 1875, see Homonyma 1956.)

—— *concavosuturata* Khalilov, **306,** p. 186, pl. 1, fig. 6. Upper Eocene, Azerbaidzhan area, USSR.

—— —— —— var. *carinata* Khalilov, **306,** p. 186, pl. 1, fig. 7. Upper Eocene, Azerbaidzhan area, USSR. (Note: Preoccupied by *Bolivina beyrichi carinata* Hantken, 1875, see Homonyma 1956.)

—— *cylindrata* Khalilov, **306,** p. 199, pl. 3, figs. 7,8. Upper Eocene, Azerbaidzhan region, USSR.

—— *decurrens* (Ehrenberg) var. *parallela* Said & Kenawy, **507,** p. 143, pl. 4, fig. 18. Maastrichtian, Sinai, Egypt. [Note: Preoccupied by *Bolivina parallela* (Perner, 1892), see Homonyma 1956.]

—— *dilatabiliformis* Khalilov, **306,** p. 188, pl. 1, fig. 9. Upper Eocene, Azerbaidzhan region, USSR.

—— *dilatabilis* Khalilov, **306,** p. 188, pl. 1, fig. 10. Upper Eocene, Azerbaidzhan area, USSR.

—— *dilatata* Reuss var. *abbreviata* Longinelli, **367,** p. 156, pl. 12, fig. 21. Calabrian, Italy. (Note: Preoccupied by *Bolivina limbata* Brady var. *abbreviata* Heron-Allen & Earland, 1924, see Homonyma 1956.)

—— *gracilis* Cushman & Applin var. *caucasica* Khalilov, **306,** p. 194, pl. 2, fig. 12. Middle-Upper Eocene, Azerbaidzhan area, USSR. (Note: Preoccupied by *Bolivina subincrassata caucasica* Khalilov, 1956, *ut infra,* see Homonyma 1956.)

—— —— —— var. *costa* Khalilov, **306,** p. 194, pl. 2, fig. 13. Upper Eocene, Azerbaidzhan area, USSR.

—— *helenae* Djanelidze, **150,** p. 116, pl. 4, fig. 2. Miocene, Georgia, USSR.

—— *hiltermanni* Hofker, **275,** p. 68, text fig. 36, Maastrichtian, Germany.

—— *intorta* Khalilov, **306,** p. 203, pl. 3, fig. 14. Upper Eocene, Azerbaidzhan area, USSR.

—— *italica* Cushman var. *substriata* Longinelli, **367,** p. 158, pl. 12, fig. 9. Calabrian, Italy. (Note: Preoccupied by *Bolivina beyrichi substriata* Reuss, 1870, see Homonyma 1956.)

—— *lafayettei* McLean, **405,** p. 346, pl. 45, figs. 6,8. Virginia, Miocene, U.S.A.

—— *maragaensis* Khalilov, **306,** p. 215, pl. 4, fig. 20. Lower Oligocene, Azerbaidzhan area, USSR.

—— *marginata* Cushman var. *monicana* Pierce, **457,** p. 1308, pl. 143, fig. 3. Upper Miocene, California, U.S.A.

—— *minutaformis* Khalilov, **306,** p. 214. Lower Eocene, Azerbaidzhan area, USSR.

—— *opima* Khalilov, **306,** p. 195, pl. 2, fig. 14. Upper Eocene, Azerbaidzhan area, USSR.

—— *ovatoformis* Khalilov, **306,** p. 205, pl. 4, fig. 1. Lower Oligocene, Azerbaidzhan area, USSR.

—— *paradaschensis* Khalilov, **306,** p. 187, pl. 1, fig. 8. Upper Eocene, Azerbaidzhan area, USSR.

—— *pocheensis* W. R. White, **617,** p. 251, pl. 29, fig. 13. Upper Miocene, California, USA.

—— *pseudogoëssii* Hofker, **273,** p. 69, pl. 7. figs. 35–42. Recent, West Indies.

—— *pseudointermedia* Khalilov, **306,** p. 215, pl. 4, figs. 18,19. Eocene, Azerbaidzhan region, USSR.

—— *praebinaensis* Khalilov, **306,** p. 208, pl. 4, fig. 5. Upper Eocene, Azerbaidzhan area, USSR.

—— —— —— var. *carinata* Khalilov, **306,** p. 210, pl. 4, fig. 8. Upper Eocene, Azerbaidzhan area, USSR. (Note: Preoccupied by *Bolivina beyrichi carinata* Hantken, 1875, see Homonyma 1956.)

—— —— —— var. *crassa* Khalilov, **306,** p. 209, pl. 4, fig. 7. Upper Eocene, Azerbaidzhan area, USSR. (Note: Preoccupied by *Bolivina incrassata crassa* Vassilenko & Mjatliuk, 1947, see Homonyma 1956.)

—— —— —— var. *subangusta* Khalilov, **306,** p. 208, pl. 4, fig. 6. Upper Eocene, Azerbaidzhan area, USSR.

—— *reticulataformis* Khalilov, **306,** p. 201, pl. 3, figs. 11,12. Upper Eocene, Azerbaidzhan area, USSR.

—— *saltakensis* Khalilov, **306,** p. 202, pl. 4, fig. 15. Upper Eocene, Azerbaidzhan area, USSR.

—— *semiintegra* Khalilov, **306,** p. 185, pl. 1, fig. 5. Upper Eocene, Azerbaidzhan area, USSR.

—— *serrata* Khalilov, **306,** p. 192, pl. 2, fig. 10. Upper Eocene, Azerbaidzhan area, USSR. [Preoccupied by: *Bolivina obsoleta* (Eley) var. *serrata* Wright, 1900, see Homonyma 1956.]

—— —— —— var. *parallela* Khalilov, **306,,** p. 193, pl. 3, fig. 11. Upper Eocene, Azerbaidzhan region, USSR. [Note: Preoccupied by *Bolivina parallela* (Perner, 1892), see Homonyma 1956.]

—— *spatuloides* Hofker, **273,** p. 66, pl. 7, fig. 8–11. Recent, West Indies.

—— *subbinaensis* Khalilov, **306,** p. 207, pl. 4, fig. 4. Upper Eocene, Azerbaidzhan area, USSR.

—— *subchlamida* Khalilov, **306,** p. 196, pl. 3, figs. 1,2. Upper Eocene, Azerbaidzhan area, USSR.

—— —— —— var. *magna* Khalilov, **306,** p. 197, pl. 3, fig. 3. Upper Eocene, Azerbaidzhan area, USSR.

—— *subincrassata* Khalilov, **306,** p. 181, pl. 1 fig. 1. Paleocene, Azerbaidzhan region, USSR.

—— —— —— var. *caucasica* Khalilov, **306,** p. 182, pl. 1, fig. 2. Paleocene to basal Eocene, Azerbaidzhan region, USSR.

—— —— —— var. *costata* Khalilov, **306,** p. 183, pl. 1, fig. 3. Lower Eocene, Azerbaidzhan area, USSR. (Note: Preoccupied by *Bolivina costata* Orbigny, 1839, see Homonyma 1956.)

—— *tarchaensis* Subbotina & Chutzieva in Djanelidze, **150,** p. 116, pl. 4, figs. 5,6. Miocene, Georgia, USSR.

—— *tuberna* Khalilov, **306,** p. 206, pl. 4, fig. 2. Upper Eocene, Azerbaidzhan area, USSR.

—— —— —— var. *gradata* Khalilov, **306,** p. 206, pl. 4, fig. 3. Upper Eocene, Azerbaidzhan area, USSR.

Bolivinita bandyi Said & Kenawy, **507,** p. 141, pl. 3, fig. 49. Danian, Sinai, Egypt.

Bolivinopsis minuta Said & Kenawy, **507,** p. 138,

pl. 3, fig. 27. Maastrichtian, Sinai, Egypt.

Boultonia cheni Ho, **258,** p. 64, pl. 1, figs. 1–7. Moscovian, Kiangsu, China.

Bradyina flosculus Ganelina, **194,** p. 106, pl. 9, figs. 3–5. Visean, Moscow Basin, USSR.

—— *modica* Ganelina, **194,** p. 107, pl. 11, figs. 1,2. Visean, Moscow Basin, USSR.

—— *sphaerica* Putrya, **476,** p. 372, pl. 1, figs. 7,8. Middle Carboniferous, Donetz Basin, USSR.

—— *sphaeroidea* Putrya, **476,** p. 372, pl. 1, figs. 12,13. Middle Carboniferous, Donetz Basin, USSR.

BRONNIMANNELLA Montanaro Gallitelli, **420,** p. 35. New genus of the family Heterohelicidae, subfamily Heterohelicininae. Upper Cretaceous. Genotype. *Gümbelina plummerae* Loetterle, 1937, Nebraska Geol. Surv., ser. 2, Bull. 12, p. 13, pl. 5, figs. 1,2. Upper Cretaceous Kansas, South Dakota and Nebraska.

Bulimina carmensis Petters & Sarmiento, **452,** p. 29, pl. 1, fig. 2. Lower Miocene, Colombia. Synonyma: *Bulimina elegans* Orbigny in Brady, 1884, Challenger Exped., Rept. Zoology, vol. 9, p. 398, pl. 50, figs. 1 and 2 (not 3 and 4); *Bulimina parkerae* Thalmann, 1942, Amer. Midland Natural., vol. 28, p. 464.

—— *dentoni* Petters & Sarmiento, **452,** p. 29, pl. 1, fig. 3. Upper Oligocene, Colombia.

—— *konkensis* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 80, pl. 9, fig. 9. Middle Miocene, Azerbaidzhan region, USSR.

—— *nammalensis* Haque, **238,** p. 127, pl. 29, fig. 6. Upper Paleocene, Pakistan.

—— *parvula* Franzenau, **187,** p. 215, pl. 1, figs. 44–46. Rupelian, Hungary.

—— *preacanthia* McLean, **405,** p. 345, pl. 45, figs. 2,3,7. Miocene, Virginia, U.S.A.

—— *pseudoquadrata* Haque, **238,** p. 124, pl. 20, fig. 2. Lower Eocene, Pakistan.

—— *pseudovata* Hofker, **271,** p. 920, text figs. 41,42. Upper Eocene, Ecuador, Synonym: *Bulimina ovata* Orbigny, in Cushman & Stainforth, 1951, Jour. Paleontology, v. 25, p. 151, pl. 26, fig. 44.

—— *scalena* Franzenau, **187,** p. 214, pl. 1, figs. 10,11. Tortonian, Yugoslavia.

—— *serratospina* Finlay subsp. *bermudezi* Haque, **234,** p. 145, pl. 13, fig. 7,8. Ledian, Italy.

Buccella anderseni McLean, **405,** p. 354, pl. 50, fig. 1; pl. 51, figs. 1,4. Miocene, Virginia, U.S.A.

Cancellina matsushitai Yamagiwa, **627,** p. 236, pl. 34, figs. 1–4. Permian, Japan.

Cancris joaquinensis H. P. Smith, **541,** p. 98, pl. 15, figs. 5,6. Oligocene, California, U.S.A.

Cassidulina bulloides Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 82, pl. 9, fig. 12. Middle Miocene, Azerbaidzhan region, USSR.

—— *kernensis* H. P. Smith, **541,** p. 100, pl. 14, figs. 1,3. Oligocene, California, U.S.A.

—— *sublaevigata* Hofker, **271,** p. 931, text fig. 59. Upper Eocene, Ecuador.

Cassidulinoides miuraensis Higuchi, **248,** p. 58, text fig. 7, nos. 1,2. Pliocene, Japan.

Charltonina canterburyensis Haynes, **244,** p. 97, pl. 17, fig. 14. Thanetian, Kent, England.

—— *toddae* Said & Kenawy, **507,** p. 152, pl. 6, fig. 15. Paleocene, Sinai, Egypt.

CHILOGUEMBELINA Loeblich & Tappan, **365,** p. 340. New genus of the family Heterohelicidae. Tertiary (Paleocene). Genotype: *Gümbelina midwayensis* Cushman, 1940, Contr. Cushman Lab. Foram. Res., v. 16, p. 65, pl. 11, fig. 15. Paleocene, Alabama.

Chilostomella comata Haque, **238,** p. 169, pl. 23, fig. 8; pl. 26, fig. 9. Paleocene, Pakistan.

CHITINOSACCUS Smitter, **542,** p. 258. New genus of the family Allogromiidae. Recent (brackish waters). Genotype: *Chitinosaccus zuluensis* Smitter, 1956, *ut infra.*

—— *zuluensis* Smitter, **542,** p. 258, text fig. 1. Recent, brackish water, Santa Lucia Bay, Zululand.

Chrysalogonium tappanae Said & Kenawy, **507,** p. 134, pl. 3, fig. 10. Upper Danian, Sinai, Egypt.

Chusenella conicocylindrica Chen, **100,** p. 43, pl. 4, figs. 7,8. Upper Permian, China.

—— *tingi* Chen, **100,** p. 41, pl. 2, figs. 1–3. Upper Permian, China.

Cibicides alleni (Plummer) var. *carinata* Haque, **238,** p. 208, pl. 20, fig. 12; pl. 33, fig. 2. Upper Paleocene, Pakistan. [Note: Preoccupied by *Cibicides carinatus* (Terquem, 1882), see Homonyma 1956.]

—— *andersoni* Petters & Sarmiento, **452,** p. 32, pl. 1, fig. 10. Upper Oligocene, Colombia.

—— *floridanus* (Cushman) var. *suturatus* Ascoli, **27,** p. 265, text fig. 1. Tortonian, Italy.

—— *hettneri* Petters & Sarmiento, **452,** p. 32, pl. 1, fig. 11. Middle Oligocene, Colombia.

—— *kismartonensis* Franzenau, **187,** p. 218, pl. 1, figs. 7–9. Tortonian, Austria.

—— *lobatulus* (Walker & Jacob) var. *patalaensis* Haque, **238,** p. 209, pl. 16, fig. 6. Paleocene, Pakistan.

—— *loeblichi* Said & Kenawy, **507,** p. 155, pl. 7, fig. 11. Paleocene, Sinai, Egypt.

—— *megaloperforatus* Said & Kenawy, **507,** p. 155, pl. 7, fig. 13. Paleocene, Sinai, Egypt.

—— *mensilla* (Schwager) var. *nammalensis* Haque, **238,** p. 206, pl. 20, fig. 10. Upper Paleocene, Pakistan.

—— *multifarius* (Schwager) var. *limbata* Haque, **238,** p. 205, pl. 26, fig. 5. Upper Paleocene, Pakistan. (Note: Preoccupied by *Cibicides subspiratus limbatus* Cita, 1950, see Homonyma 1956.)

—— *nekhlianus* Said & Kenawy, **507,** p. 155, pl. 7, fig. 9. Maastrichtian, Sinai, Egypt.

—— *pseudowuellerstorfi* Cole subsp. *gigas* Hagn, **234,** p. 182, pl. 18, figs. 1,2. Ledian, Italy.

—— *romhanyensis* Franzenau **187,** p. 216, pl. 1, figs. 15–17. Tortonian, Austria.

—— *schwageri* Said & Kenawy, **507,** p. 155, pl. 7, fig. 10. Danian, Sinai, Egypt.

—— *tappanae* Said & Kenawy, **507,** p. 155, pl. 7, fig. 12. Maastrichtian, Sinai, Egypt.

Clavulina paxilliformis Haque, **238,** p. 49, pl. 12, figs. 6,8. Paleocene, Pakistan.

—— —— —— var. *symmetrica* Haque, **238,** p. 50, pl. 24, fig. 6. Paleocene, Pakistan.

Clavulinoides filiformis Marie, **392,** p. B-238, pl. 1, figs. 5,6. Upper Cretaceous, Belgium.

—— *hofkeri* Marie, **392,** p. B-237, pl. 1, figs. 9–12. Upper Cretaceous, Belgium.

— *lakiensis* Haque, **238,** p. 43, pl. 21, fig. 7; pl. 32, fig. 1. Lower Eocene, Pakistan.
—— —— —— var. *elongata* Haque, **238,** p. 45, pl. 21, fig. 13. Upper Paleocene, Pakistan.
—— —— —— var. *limbata* Haque, **238,** p. 45, pl. 21, fig. 8. Upper Paleocene, Pakistan.
—— —— —— var. *spatha* Haque, **238,** p. 44, pl. 21, fig. 6. Upper Paleocene, Pakistan.
Climacammina ferra Cummings, **134,** p. 228, pl. 1, fig. 13, 14; text fig. 16. Lower Carboniferous, Scotland.
—— *padunensis* Ganelina, **194,** p. 80, pl. 4, figs. 7,8. Visean, Moscow Basin, USSR.
—— *supraparva* Cummings, **134,** p. 227, pl. 1, fig. 12; text fig. 15. Namurian, Scotland.
COCHLEATINA Bykova, **85,** p. 12. New genus of the family Lagenidae. Ordovician. Genotype: *Cochleatina plavinensis* Bykova, 1956, *ut infra.*
—— *plavinensis* Bykova, **85,** p. 13, pl. 1, figs. 8–10. Middle Ordovician, Baltic States.
Codonofusiella lui Sheng, **528,** p. 207, pl. 3, figs. 1–4. Permian, China.
—— *schubertelloides* Sheng, **528,** p. 208, pl. 4, figs. 1–14. Permian, China.
—— *tenuissima* Sheng, **528,** p. 209, pl. 4, figs. 15,16. Permian, China.
Codonofusiella ? minuta Sheng, **528,** p. 210, pl. 4, figs. 17,18. Permian, China.
Coleites ornatus Haque, **238,** p. 143, pl. 12, figs. 3–5. Upper Paleocene, Pakistan.
Cornuspira captiosa Ganelina, **194,** p. 65, pl. 1, figs. 2,3. Visean, Moscow Basin, USSR.
Coskinolinoides jamaicensis Cole, **112,** p. 216, pl. 24, figs. 12–16; pl. 31, figs. 3,4. Middle Eocene, Jamaica.
COXITES Smout, **543,** p. 342. New genus of the family Ceratobuliminidae. Turonian. Genotype: *Coxites zubairensis* Smout, 1956, *ut infra.*
—— *zubairensis* Smout, **543,** p. 343, pl. 2, figs. 1–6. Lower Turonian, Iraq.
Cribroelphidium asakense Fujita, **193,** p. 233, pl. 8, fig. 7. Pliocene, Japan.
—— *pacificum* Ujiié, **594,** p. 273, pl. 14, figs. 9–14. Recent, beach sand, Japan.
CRIBROENDOTHYRA Lebedeva, **350,** p. 46. New genus of the family Endothyridae. Lower Carboniferous. Genotype: *Cribroendothyra No. 1,* sp. et gen. nov. Lebedeva, 1956, *ut infra.*
—— *No. 1* Lebedeva, **350,** p. 47, pl. 3, fig. 4. Lower Tournaisian, Tengiszkaya depression, USSR.
Cribrogloborotalia challinori Haque, **238,** p. 189, pl. 14, fig. 6. Paleocene, Pakistan.
—— *platti* Haque, **238,** p. 190, pl. 34, fig. 4. Paleocene, Pakistan.
Cribrostomum inflatum Cummings, **134,** p. 223, pl. 1, fig. 8. Lower Carboniferous, Scotland.
—— *linnum* Cummings, **134,** p. 223, pl. 1, fig. 9. Namurian, Scotland.
—— *oveyi* Cummings, **138,** p. 223. Not figured. Synonym: *Textularia eximia* Eichwald in Brady, 1876, Monogr. Carbon. and Perm. Foram., p. 132, pl. 10, figs. 27–29, Lower Carboniferous, England.
—— *ponielum* Cummings, **138,** p. 222, pl. 1, fig. 7. Lower Carboniferous, Scotland.
—— *scoticum* Cummings, **138,** p. 220, pl. 1, fig. 5; text fig. 11. Lower Carboniferous, Scotland.
—— *wilkiestoni* Cummings, **138,** p. 221, pl. 1, fig. 6; text fig. 12. Lower Carboniferous, Scotland.
Cribrostomoides paralens Omara, **435,** p. 887, pl. 102, figs. 1–3; text fig. 3, nr. 3. Cenomanian, Sinai, Egypt.
—— *sinaica* Omara, **435,** p. 886, pl. 102, figs. 4–6; text fig. 3, nrs. 1,2,4. Cenomanian, Sinai, Egypt.
Cristellaria (*Astacolus*) *kuznesovi* Mamontova, **387,** p. 35, pl. 1, fig. 14. Upper Liassic, northwestern Caucasus, USSR.
—— (*Lenticulina*) *subalatiformis* Dain, in Mamontova, **387,** p. 31, pl. 2, fig. 7. Upper Liassic, northwestern Caucasus, USSR. Synonym: *Cristellaria cultrata* Orbigny in Issler, 1908, Palaeontogr., v. 55, Nr. 88, pl. 7, figs. 313 and 316.
Cyclammina pozoensis Berry, **53,** (no information available). Eocene, Peru.
—— *senegalensis* Colom, **115,** p. 35, text figs. 1–11. Recent, off Cape Manuel, Senegal.
—— *verdunensis* Berry, **53,** (no information available), Eocene, Peru.
Cycloloculina glabra Wood & Haque, **624,** p. 41, pl. 7, text fig. 1. Paleocene and Lower Eocene. Pakistan.
Cylindroclavulina colomi Hagn, **234,** p. 123, pl. 10, figs. 6,7; pl. 18, figs. 8–9. Ladian, Italy. Synonym: *Liebusella* (*?*) *eocaena* (Gümbel) in Cushman, 1937, Cushman Lab. Foram. Res., Spec. Pub. No. 8, p. 163, pl. 19, fig. 13 (non 14); and in Hagn, 1954, N. Jahrb. Geol. Paläont., Abhandl., v. 98, p. 419, pl. 26, fig. 1.
Cymbaloporetta tortonica Franzenau & Majzon, **187,** p. 217, pl. 1, figs. 4–6. Tortonian, Yugoslavia.
Darbyella macfadyeni Bartenstein, **45,** p. 517, pl. 2, fig. 51; text fig. 4. Hauterivian, England.
Daviesina intermedia Smout & Haque, **544,** p. 54, pl. 10, figs. 4–6. Paleocene, Pakistan.
Deckerella conquisita Ganelina, **194,** p. 79, pl. 4, fig. 9. Visean, Moscow Basin, USSR.
—— *cylindrica* Putrya, **476,** p. 374, pl. 2, fig. 8. Middle Carboniferous, Donetz Basin, USSR.
—— *quadrata* Cummings, **134,** p. 232, pl. 1, fig. 15. Lower Carboniferous, Scotland.
Dentalina bischgonensis Mamontova, **387,** p. 26, pl. 2, fig. 3. Upper Liassic, northwestern Caucasus, USSR.
—— *filiformis* Orbigny var. *substriata* Longinelli, **367,** p. 121, pl. 7, fig. 1. Calabrian, Italy.
—— *ghorabi* Said & Kenawy, **507,** p. 133, pl. 2, fig. 27. Maastrichtian, Sinai, Egypt.
—— *globifera* (Reuss) var. *nammalensis* Haque, **238,** p. 139, pl. 23, fig. 1. Lower Eocene, Pakistan.
—— *kaicherae* McLean, **405,** p. 328, pl. 38, figs. 14,15,18,19. Miocene, Virginia, U.S.A.
—— *monicana* Pierce, **457,** p. 1302, pl. 137, fig. 3. Upper Miocene, California, U.S.A.
—— *striatopunctata* Parker & Jones var. *pentacosta* Pierce, **457,** p. 1302, pl. 137, fig. 6. Upper Miocene, California, U.S.A.

Dentalina (?) vomeriformis Haque, **238,** p. 78, pl. 23, fig. 9. Lower Eocene, Pakistan.

DEUTEROFORAMINATA Hofker, **273,** p. 167. New suborder of the Foraminifera. Includes the families Conorbidae, Pulvinulinidae, Gavelinellidae, Marginolamellidae, Cympaloporettidae, Tinoporidae, Valvulineridae, and Globigerinidae.

Dictyconus reicheli Guillaume, **231,** p. 141, pl. 1, figs. 1–8; text fig. 1. Barremian-Aptian, Switzerland.

Discocyclina senegalensis Abrard, **4,** p. 237, pl. 11, figs. 1–7; text fig. 1. Lutetian, Senegal.

Discopulvinulina crassipara Hofker, **273,** p. 182, pl. 27, figs. 9–17. Recent, West Indies.

Discorbis conicus Djanelidze, **150,** p. 119, pl. 4, figs. 15–18. Miocene, Georgia, USSR. (Note: Preoccupied by *Discorbis conica* van Bellen, 1945, see Homonyma 1956).

—— *elatoumbonatus* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 131, pl. 18, fig. 10. Upper Sarmatian, Azerbaidzhan, USSR.

—— *gigae* Djanelidze, **150,** p. 119, pl. 3, fig. 19; pl. 4, fig. 14. Miocene, Georgia, USSR.

—— *kerekhegyensis* Franzenau, **187,** p. 217, pl. 1, figs. 12–14. Tortonian, Yugoslavia.

—— *leo* Djanelidze, **150,** p. 118, pl. 4, fig. 3. Miocene, Georgia, USSR.

—— *norrisi* Mellon & Wall, **406,** p. 15, pl. 2, figs. 9–11. Middle Albian, Western Canada.

—— *rehderi* McLean, **405,** p. 353, pl. 46, figs. 13,14. Miocene, Virginia, U.S.A. Synonyma: *Discorbis rosacea* Orbigny in Cushman, 1918, U. S. Geol. Surv. Bull. 676, p. 59, pl. 14, fig. 4; and *Rotorbinella ? rosacea* (Orbigny) in Puri, 1953, Florida Geol. Surv., Bull. 36, p. 136, pl. 24, figs. 1–3.

Dorothia pupoides (Orbigny) var. *nammalensis* Haque, **238,** p. 53, pl. 32, fig. 4. Lower Eocene, Pakistan.

—— *sinaensis* Said & Kenawy, **507,** p. 128, pl. 2, fig. 1. Lower Eocene, Sinai, Egypt.

—— *textularioides* Marie, **392,** p. B-239, pl. i, fig. 8. Upper Cretaceous, Belgium. [Note: Preoccupied by *Dorothia textilarioides* (Hantken, 1876), see Homonyma 1956.]

DUTKEVICHELLA Putrya, **476,** p. 460. New genus of the family Fusulinidae, subfamily Fusulininae. Middle Carboniferous. Genotype: *Fusulina dutkevichi* Putrya, 1937, Azov-Black Sea Geol. Trust, Geol. Min. Resources, Contr. (Materially), v. 1, p. 68, pl. 2, fig. 18, Middle Carboniferous, Bolshoi-Donbass, USSR.

Ellipsoglandulina allisi Said & Kenawy, **507,** p. 146, pl. 4, fig. 34. Maastrichtian, Sinai, Egypt.

Elphidium advena (Cushman) var. *miyatense* Fujita, **193,** p. 231, pl. 8, fig. 3. Pleistocene, Japan.

—— *alizadei* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 78, pl. 9, fig. 4. Miocene (middle), Azerbaidzhan, USSR.

—— *azizbekovi* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 78, pl. 9, fig. 3. Middle Miocene, Azerbaidzhan, USSR.

—— *bosoense* Fujita, **193,** p. 232, pl. 8, fig. 6. Recent, beach sand, Japan.

—— *crispum* (Linné) var. *robusta* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 125, pl 17, fig. 3. Lower and Middle Sarmatian, Azerbaidzhan, USSR.

—— *johnstonae* McLean, **405,** p. 343, pl. 42, figs. 9,18; pl. 44, figs. 3–5,7. Miocene, Virginia, U.S.A.

—— *kaicherae* McLean, **405,** p. 343, pl. 42, figs. 11,13–17. Miocene, Virginia, U.S.A.

—— *kvesanensis* Artchvadze, **150,** p. 109, pl. 3, fig. 2. Miocene, Georgia, USSR.

—— *mariae* Artchvadze, **150,** p. 110, pl. 3, figs. 10,11. Miocene, Georgia, USSR.

—— *miusserensis* Djanelidze, **150,** p. 109, pl. 3, fig. 4. Miocene, Georgia, USSR.

—— *phrenidae* Djanelidze, **150,** p. 110, pl. 3, fig. 3. Miocene, Georgia, USSR.

—— *rugosum* (Orbigny) var. *djalairica* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 126, pl. 17, fig. 5. Lower and Middle Sarmatian, Azerbaidzhan, USSR.

—— *tumidum* (Bogdanowicz) var. *umbilicata* Djanelidze, **150,** p. 111, pl. 3, fig. 1. Miocene, Georgia, USSR. [Note: Preoccupied by *Elphidium umbilicatum* (Orbigny, 1826), see Homonyma 1956.]

—— *venustum* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 128, pl. 17, fig. 10. Lower Sarmatian, Azerbaidzhan, USSR. [Note: Preoccupied by *Elphidium venustum* (Schultze, 1854), see Homonyma 1956.]

ENANTIOAMPHICORYNA Marie, **392,** p. B-243. New genus (family not stated: Lagenidae ?). Campanian. Genotype: *Enantioamphicoryna obesa* Marie, 1956, *ut infra.*

—— *obesa* Marie, **392,** p. B-244, pl. 2, figs. 5,6. Campanian, Belgium.

Endothyra archaediscoidea Ganelina, **194,** p. 96, pl. 7, fig. 7. Visean, Moscow Basin, USSR.

—— *apposita* Ganelina, **194,** p. 89, pl. 6, figs. 7,8. Visean, Moscow Basin, USSR.

—— *celsa* Ganelina, **194,** p. 97, pl. 7, fig. 8. Visean, Moscow Basin, USSR.

—— *communis* Rauser-Chernoussova var. *umbilicata* Lebedeva, **350,** p. 43, pl. 1, figs. 12,13. Lower Tournaisian, Tengizskaya depression, USSR.

—— *dorogobuzhica* Ganelina, **194,** p. 95, pl. 7, fig. 6. Visean, Moscow Basin, USSR.

—— *excelsa* Ganelina, **194,** p. 92, pl. 6, fig. 11. Visean, Moscow Basin, USSR.

—— *explicata* Ganelina, **194,** p. 90, pl. 6, figs. 9, 10. Visean, Moscow Basin, USSR.

—— *expressa* Ganelina, **194,** p. 88, pl. 6, fig. 1. Visean, Moscow Basin, USSR.

—— *frequentata* Ganelina, **194,** p. 94, pl. 7, figs. 4,5. Visean, Moscow Basin, USSR.

—— *geniculata* Ganelina, **194,** p. 88, pl. 6, figs. 5,6. Visean, Moscow Basin, USSR.

—— *klubovi* Lebedeva, **350,** p. 45, pl. 2, fig. 2. Lower Tournaisian, Tengizskaya depression, USSR.

—— *konensis* Lebedeva, **350,** p. 44, pl. 1, fig. 11. Lower Tournaisian, Tengizskaya depression, USSR.

—— *korbensis* Ganelina, **194,** p. 98, pl. 9, figs. 1,2. Visean, Moscow Basin, USSR.

—— *ovalis* Ganelina, **194,** p. 97, pl. 8, figs. 1,2. Visean, Moscow Basin, USSR.
—— *posneri* Ganelina, **194,** p. 86, pl. 5, figs. 10,11. Visean, Moscow Basin, USSR.
—— *stalinogorski* Ganelina, **194,** p. 93, pl. 7, fig. 1. Visean, Moscow Basin, USSR.
—— *sulcata* Ganelina, **194,** p. 87, pl. 6, fig. 2. Visean, Moscow Basin, USSR.
—— *tatianae* Ganelina, **194,** p. 91, pl. 6, figs. 12, 13. Visean, Moscow Basin, USSR. (Note: *Cave Endothyra radiata* Brady, 1869, var. *tateana* Howchin, 1888.)
—— *tengisica* Lebedeva, **350,** p. 45, pl. 2, fig. 1. Lower Tournaisian, Tengizskaya depression, USSR.
—— *umbonata* Ganelina, **194,** p. 99, pl. 10, figs. 1,2. Visean, Moscow Basin, USSR.
—— *wjasmensis* Ganelina, **194,** p. 93, pl. 7, figs. 2,3. Visean, Moscow Basin, USSR.
Endothyranella graciosa Putrya, **476,** p. 370, pl. 1, fig. 4. Middle Carboniferous, Don Basin, USSR.
ENDOTHYRANOPSINAE Reitlinger, 1956. Cited from: Reitlinger, 1958, Voprosy Mikropaleont., Nr. 2, Akad. Nauk SSSR., p. 57 (original publication of 1956 not available to compiler). New subfamily of the family Endothyridae. Upper Lower Carboniferous. Comprises the genera: *Bradyina* Möller, 1878; *Glyphostomella* Cushman & Waters, 1928; *Pseudobradyina* Reitlinger, 1950; *Endothyranopsis* Cummings, 1955.
Entosolenia adriana Longinelli, **367,** p. 139, pl. 9, fig. 2. Calabrian, Italy.
—— *elongata* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 133, pl. 18, fig. 12. Sarmatian, Azerbaidzhan, USSR.
—— *excellens* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 133, pl. 18, fig. 13. Upper Sarmatian, Azerbaidzhan, USSR.
—— *georgiana* Djanelidze, **150,** p. 103, pl. 1, fig. 12. Upper Miocene, Georgia, USSR.
—— *maciae* Djanelidze, **150,** p. 103, pl. 1, fig. 13. Upper Miocene, Georgia, USSR.
—— *ornata* Terquem & Terquem var. *compressa* Longinelli, **367,** p. 138, pl. 9, fig. 17. Calabrian, Italy. [Note: Preoccupied by *Entosolenia compressa* (Orbigny, 1839), see Homonyma 1956.]
—— *ovulum* Subbotina & Chutzieva in Djanelidze, **150,** p. 102, pl. 1, fig. 11. Upper Miocene, Georgia, USSR.
—— *trigono-marginata* Parker & Jones var. *striata* Longinelli, **367,** p. 136, pl. 9, fig. 16. Calabrian, Italy.
—— *vadensis* Longinelli, **367,** p. 140, pl. 9, fig. 13. Calabrian, Italy.
—— see also *Lagena.*
Eofusulina binominata Putrya, **476,** p. 457, pl. 15, figs. 4–6. Middle Carboniferous, Don Basin, USSR.
—— (*Paraeofusulina*) *subtilissima* Putrya, **476,** p. 459, pl. 15, fig. 9. Middle Carboniferous, Don Basin, USSR.
—— (——) *trianguliformis* Putrya, **476,** p. 458, pl. 15, figs. 7,8. (Subgenotype of subgenus *Paraeofusulina* Putrya, 1956, *ut infra.*) Middle Carboniferous, Don Basin, USSR.
EOFUSULININAE Rauser-Chernoussova & Rozovskaja, 1956. New subfamily of family Fusulinidae. Middle Carboniferous. Includes the genera: *Verella* Dalmatskaya, 1952, and *Eofusulina* Rauser-Chernoussova, 1951. (Original publication not seen by compiler. Cited from: Miklukho-Maklaj, Rauser-Chernoussova & Rozovskaja, 1958, Voprosy Mikropaleont., No. 2, Akad. Nauk. SSSR, p. 17.)
EOLASIODISCUS Reitlinger, **487,** p. 75. New genus (family not stated). Carboniferous. Genotype: *Eolasiodiscus donbassicus* Reitlinger, 1956, *ut infra.*
—— *donbassicus* Reitlinger, **487,** p. 76, pl. 2, figs. 3,4. Carboniferous, USSR.
—— *galinae* Reitlinger, **487,** p. 76, pl. 2, figs. 5–7. Carboniferous, USSR.
EOSIGMOILINA Ganelina, in Kiparisova, et al., **312,** p. 17. New genus of the family Miliolidae. Middle Carboniferous. Genotype: *Eosigmoilina explicata* Ganelina, 1956, *ut infra.*
—— *explicata* Ganelina in Kiparisova et al., **312,** p. 18, pl. 2, figs. 6–8. Middle Carboniferous (Bashkirian), Denprovsk-Donetz Basin, USSR.
—— *radtchenkovensis* Ganelina in Kiparisova et al., **312,** p. 18, pl. 2, fig. 9. Middle Carboniferous, USSR.
Eostaffella accepta Ganelina, **194,** p. 111, pl. 11, figs. 12,13. Visean, Moscow Basin, USSR.
—— *depressa* Putrya, **476,** p. 380, pl. 3, figs. 2–4.7. Middle Carboniferous, Don Basin, USSR.
—— *galinae* Ganelina, **194,** p. 113, pl. 12, figs. 3,4. Visean, Moscow Basin, USSR.
—— *irenae* Ganelina, **194,** p. 115, pl. 12, figs. 5,6. Visean, Moscow Basin, USSR.
—— *oblonga* Ganelina, **194,** p. 114, pl. 12, fig. 8. Visean, Moscow Basin, USSR.
—— *ovesa* Ganelina, **194,** p. 110, pl. 11, figs. 10, 11. Visean, Moscow Basin, USSR.
—— *raguschensis* Ganelina, **194,** p. 112, pl. 12, figs. 1,2. Visean, Moscow Basin, USSR.
—— *schwetzovi* Ganelina, **194,** p. 109, pl. 11, figs. 8,9. Visean, Moscow Basin, USSR.
Eouvigerina hofkeri Said & Kenawy, **507,** p. 141, pl. 3, fig. 50. Danian, Sinai, Egypt.
Epistomina decorata Kaptarenko-Chernoussova, **300,** p. 60, pl. 1, fig. 19. Lower Callovian, USSR.
—— *dneprica* Kaptarenko-Chernoussova, **300,** p. 60, pl. 1, fig. 26. Middle Callovian, USSR.
—— *elschankaensis* Mjatliuk var. *poltavica* Kaptarenko-Chernoussova, **300,** p. 60, pl. 1, fig. 22. Middle Callovian, USSR.
—— *limbata* Kaptarenko-Chernoussova, **300,** p. 60, pl. 1, fig. 27. Oxfordian, USSR. (Preoccupied by: *Epistomina limbata* Tappan, 1943, see Homonyma 1956.)
—— *peregrina* Kaptarenko-Chernoussova, **300,** p. 60, pl. 1, fig. 18. Upper Bajocian, USSR.
—— *mosquensis* (Uhlig) var. *ukrainica* Kaptarenko-Chernoussova, **300,** p. 60, pl. 1, figs. 20,25. Middle Callovian, USSR.
—— *uhligi* Kaptarenko-Chernoussova, **300,** p. 60, pl. 1, fig. 29. Lower Oxfordian, USSR.
Epistominella discorbisoides Pierce, **457,** p. 1304,

pl. 139, fig. 13. Upper Miocene, California U.S.A.,
—— *dubia* Haque, **238,** p. 145, pl. 20, fig. 1. Paleocene, Pakistan.
—— *pontoni* (Cushman) var. *californica* W. R. White, **617,** p. 257, pl. 31, fig. 9. Upper Miocene, California, U.S.A.
Eponides italicus Hagn, **234,** p. 163, pl. 14, fig. 8. Ledian, Italy.
—— *mariei* Said & Kenawy, **507,** p. 148, pl. 5, fig. 2. Maastrichtian, Sinai. Egypt.
—— *nathani* Hagn, **234,** p. 162, pl. 14, fig. 7. Ledian, Italy.
—— *scheibei* Petters & Sarmiento, **452,** p. 31, pl. 1, fig. 8. Middle Oligocene, Colombia.
—— *sigali* Said & Kenawy, **507,** p. 148, pl. 5, fig. 6. Maastrichtian, Sinai, Egypt.
Eponides ? anconensis Hofker, **371,** p. 951, text fig. 91. Late middle Eocene, Ecuador. Synonym: *Eponides cocoaensis* Cushman in Cushman & Stainforth, 1951, Jour. Paleontology, v. 25, p. 159, pl. 27, fig. 31.
Fabiania indica Nagappa, **425,** p. 192, pl. 30, figs. 1–9; pl. 31, figs. 1–3; text figs. 1,2. Middle to Upper Eocene, Assam, India.
Fabularia verseyi Cole, **112,** p. 219, pl. 26, figs. 1–6. Upper Eocene, Jamaica. Synonym: *Fabularia* (*?*) sp. Hanzawa, 1937, Jour. Paleontology, v. 11, p. 113, figs. 3,5,6.
Fissurina szobensis Franzenau, **187,** p. 217, pl. 1, figs. 21,22. Tortonian, Yugoslavia.
—— *tricostulata* Pierce, **457,** p. 1302, pl. 137, fig. 7. Upper Miocene, California, U.S.A.
Flabellinella varignanoensis Hagn, **234,** p. 140, pl. 12, figs. 13,14. Ledian, Italy.
Frankeina crassa Kaptarenko-Chernoussova, **298,** p. 38, pl. 3, fig. 12. Eocene, Ukraine, USSR.
Frondicularia linearis Franke var. *nammalensis* Haque, **238,** p. 90, pl. 21, figs. 3,4. Topmost Paleocene, Pakistan.
—— *subhunteri* Hofker, **271,** p. 903, text fig. 14. Upper Eocene, Ecuador.
Fusulina angusta Putrya, **476,** p. 450, pl. 13, fig. 3. Middle Carboniferous, Don Basin, USSR.
—— *ellipsoformis* Putrya, **476,** p. 442, pl. 11, fig. 11. Middle Carboniferous, Don Basin, USSR.
—— *fallsensis* Thompson, Verville & Lokke, **577,** p. 799, pl. 89, figs. 12–23. Missourian, Missouri and Kansas, U.S.A.
—— *grigorovichi* Putrya, **476,** p. 444, pl. 11, fig. 10. Middle Carboniferous, Don Basin, USSR.
—— *isvariensis* Putrya, **476,** p. 451, pl. 13, figs. 4,7,8. Middle Carboniferous, Don Basin, USSR.
—— *pseudokayi* Putrya, **476,** p. 449, pl. 13, figs. 1,2. Middle Carboniferous, Don Basin, USSR.
—— *rossoschanica* Putrya var. *grandis* Putrya, **476,** p. 454, pl. 14, figs. 6,7. Middle Carboniferous, Don Basin, USSR.
—— *septata* Putrya, **476,** p. 440, pl. 11, fig. 5. Middle Carboniferous, Don Basin, USSR.
—— *subdistenta* Putrya, **476,** p. 438, pl. 11, figs. 1–3. Middle Carboniferous, Don Basin, USSR.
—— *weintzi* Verville, Thompson & Lokke, **602,** p. 1285, pl. 136, figs. 1–7. Pennsylvanian, Nevada, U.S.A.
Fusulinella alta Verville, Thompson & Lokke, **602,** p. 1282, pl. 134, figs. 1–12; pl. 135, figs. 7–10. Pennsylvanian, Nevada, U.S.A.
—— *nevadensis* Verville, Thompson & Lokke, **602,** p. 1283, pl. 135, figs. 1–6. Pennsylvanian, Nevada, U.S.A.
—— *paraiowensis* Putrya, **476,** p. 425, pl. 9, figs. 14,15. Middle Carboniferous, Don Basin, USSR.
—— *pseudocolaniae* Putrya, **476,** p. 429, pl. 10, figs. 7–10. Middle Carboniferous, Don Basin, USSR.
—— *subpulchra* Putrya var. *submesopachys* Putrya, **476,** p. 427, pl. 10, fig. 5. Middle Carboniferous, Don Basin, USSR.
Gallowaiinella minima Chen, **100,** p. 21, pl. 1, figs. 22–24. Upper Permian, China.
GARANTELLA Kaptarenko-Chernoussova, **300,** p. 55. New genus of the family Epistominidae. Middle Bajocian. Genotype: *Garantella rudia* Kaptarenko-Chernoussova, 1956, *ut infra.*
—— *floscula* Kaptarenko-Chernoussova, **300,** p. 60, pl. 1, fig. 5. Middle Bajocian, USSR.
—— *marginata* Kaptarenko-Chernoussova, **300,** p. 60, pl. 1, fig. 14. Middle Bajocian, USSR.
—— *rudia* Kaptarenko-Chernoussova, **300,** p. 60, pl. 1, fig. 13. Middle Bajocian, USSR.
—— *stellata* Kaptarenko-Chernoussova, **300,** p. 60, pl. 1, fig. 16. Middle Bajocian, USSR.
Gaudryina daviesi Haque, **238,** p. 37, pl. 31, fig. 14. Upper Paleocene, Pakistan.
—— *elegantissima* Said & Kenawy, **507,** p. 123, pl. 1, fig. 21. Danian, Sinai, Egypt.
—— *globosa* Kaptarenko-Chernoussova, **298,** p. 53, pl. 2, figs. 16,17. Eocene, Ukrainia, USSR.
—— *kerekhegyensis* Franzenau, **187,** p. 217, pl. 1, fig. 38. Tortonian, Yugoslavia.
—— *laevigata* Franke var. *elongata* Haque, **238,** p. 36, pl. 9, fig. 5. Upper Paleocene, Pakistan. (Note: Preoccupied by *Gaudryina ruthenica elongata* Dunikowski, 1867, see Homonyma 1956.)
—— *limbata* Said & Kenawy, **507,** p. 123, pl. 1 fig. 23. Danian, Sinai, Egypt.
—— *nekhlensis* Said & Kenawy, **507,** p. 124, pl. 1, fig. 24. Upper Paleocene, Sinai, Egypt.
—— *supracretacea* Hofker, **275,** p. 64, text fig. 7. Maastrichtian, Germany.
Gaudryina (*Pseudogaudryina*) *pyramidata* Cushman var. *nitida* Haque, **238,** p. 41, pl. 9, fig. 2. Lower Eocene, Pakistan.
—— (*Siphogaudryina*) *carinata* Franke var. *nammalensis* Haque, **238,** p. 40, pl. 3, fig. 2. Lower Eocene, Pakistan.
Gaudryinella tealbyensis Bartenstein, **45,,** p. 513, pl. 3, fig. 63; text fig. 3. Hauterivian, England.
Gavelinella brotzeni Said & Kenawy, **507,** p. 147, pl. 4, fig. 47. Maastrichtian, Sinai, Egypt.
—— —— —— var. *paleocenica* Said & Kenawy, **507,** p. 148, pl. 4, fig. 44. Upper Paleocene, Sinai, Egypt.
—— *pertusa* (Marsson) subsp. *maestrichtiensis* Hofker, **275,** p. 73, text fig. 60, Maastrichtian, Germany.
—— see also *Anomalina.*

GAVELINELLIDAE Hofker, **271,** p. 946. New family including the following genera: *Gavelinella* Brotzen, 1942; *Gavelinopsis* Hofker, 1951, and *Gavelinonion* Hofker, 1951.

Gavelinopsis atlantica Hofker, **273,** p. 212, pl. 32, figs. 12–18. Recent, West Indies.

—— *bartensteini* Hofker, **275,** p. 74, pl. 30, fig. 64. Maastrichtian, Germany.

—— *involutiformis* Hofker, **275,** p. 74, fig. 63. Maastrichtian, Germany.

Glabratella sulcata, Grell, **222,** p. 367, text figs. 1,2. Recent, Atlantic.

Glandulina antiqua Said & Kenawy, **507,** p. 137, pl. 3, fig. 22. Danian, Sinai, Egypt.

GLOBANOMALINA Haque, **238,** p. 147. New genus of the family Rotaliidae. Paleocene to Lower Eocene. Genotype: *Globanomalina ovalis* Haque, 1956, *ut infra.*

—— *ovalis* Haque, **238,** p. 148, pl. 14, fig. 3. Upper Paleocene, Pakistan.

—— —— —— var. *lakiensis* Haque, **238,** p. 149 pl. 14, fig. 2. Upper Paleocene, Pakistan.

—— *simplex* Haque, **238,** p. 149, pl. 30, fig. 2. Upper Paleocene-Lower Eocene, Pakistan.

—— —— —— var. *orbicularis* Haque, **238,** p. 149, pl. 27, fig. 9. Upper Paleocene, Pakistan.

Globigerina biforaminata Hofker, **275,** p. 76, text figs. 68,71. Maastrichtian, Germany.

—— *dubia* Egger var. *lakiensis* Haque, **238,** p. 174, pl. 4, fig. 2. Upper Paleocene-Lower Eocene, Pakistan.

—— *paratriloculinoides* Hofker, **271,** p. 956, text fig. 99. Paleocene, Ecuador.

—— *paravenezuelana* Hofker, **271,** p. 953, text figs. 93,94. Upper Eocene, Ecuador. Synonym: *Globigerina triloculinoides* (*?*) Stainforth, 1948, Jour. Paleontology, v. 22, p. 117, pl. 25, figs. 32,33.

—— *protoreticulata* Hofker, **271,** p. 954, text fig. 95. Upper Eocene, Ecuador.

—— *pseudocretacea* Hofker, **271,** p. 955, text fig. 98. Late middle Eocene, Ecuador. Synonym: *Globigerina wilsoni* (*?*) Stainforth, 1948, Jour. Paleontology, v. 22, p. 117, pl. 26, figs. 1–3.

—— *rubescens* Hofker, **273,** p. 234, pl. 35, figs. 18–21. Recent, Malayan Archipelago.

—— *stainforthi* Hofker, **271,** p. 955, text figs. 96,97. Upper Eocene, Ecuador. (Note: Preoccupied by *Globigerina stainforthi* Brönnimann, 1952, see Homonyma 1956.)

Globigerinella alexi Haque, **238,** p. 177, pl. 27, fig. 7. Upper Paleocene, Pakistan.

Globigerinoides glomerosa Blow, **63,** p. 64, text fig. 1, nrs. 15–19; text fig. 2, nrs. 1,2. Miocene, Trinidad, British West Indies.

—— —— —— subsp. *circularis* Blow, **63,** p. 65, text fig. 2, nrs. 3,4. Miocene, Trinidad, B.W.I. Synonym: *Orbulina suturalis* Brönnimann, 1951, (p.p.), Contr. Cushman Found. Foram. Research, v. 2, p. 135, text fig. 2, nrs. 3,4,9 and 14.

—— —— —— subsp. *curva* Blow, **63,** p. 64, text fig. 1, nrs. 9–14. Miocene, Trinidad, B.W.I.

—— *macrostoma* Hagn, **234,** p. 173, pl. 16, fig. 11. Ledian, Italy.

—— *transitoria* Blow, **63,** p. 65, text fig. 2, nrs. 12–15. Miocene, Trinidad, B.W.I.

Globobulimina aperta Hofker, **273,** p. 56, pl. 5, figs. 15,16; pl. 6, figs. 1–4. Recent, West Indies.

—— *pacifica* Cushman var. *curtata* W. R. White, **617,** p. 254, pl. 30, fig. 10. Lower Pliocene, California, U.S.A.

GLOBOBULIMINIDAE Hofker, **271,** p. 908. New family including the following genera: *Globobulimina* Cushman, 1927; *Stainforthia* Hofker, 1956, *ut infra; Praeglobobulimina* Hofker, 1951, and *Protoglobobulimina* Hofker, 1951.

GLOBOCONUSA Khalilov, **307,** p. 234 ? (Publication not seen by compiler).

—— *conusa* Khalilov, **307,** Genotype. (No information available to compiler.)

GLOBOENDOTHYRA Reitlinger, 1956. New genus of the family Endothyridae, subfamily Plectogyrinae. Lower Carboniferous. Genotype: *Globoendothyra pseudoglobulus* Reitlinger, 1956, nom. nov. for: *Endothyra globulus* Möller, 1878, non Eichwald, 1860. (Note: original publication by Reitlinger not available to compiler; cited from Reitlinger, 1958, Voprosy Mikropal. v. 2, Akad. Nauk SSR., p. 57).

—— *pseudoglobulus* Reitlinger, 1956, nom. nov. New name for *Endothyra globulus* Möller, 1878, Mém. Acad. Imp. Sci. St. Petersbourg, ser. 7, vol. 25, no. 9, p. 98, pl. 4, fig. 4; pl. 13, figs. 1–4, non *Nonionina globulus* Eichwald, 1860, Lethaea Rossica, v. 1, p. 350, pl. 22, fig. 17, assigned to *Endothyra* by Brady, 1876. (Reitlinger's original paper not available to compiler).

Globotruncana aspera Hofker, **269,** p. 327, text figs. 14,15. Upper Lower Campanian to lower Upper Campanian, Northwest Germany.

—— *linneiformis* Hofker, **269,** p. 326, text figs. 11–13. Lower Coniacian to lower Campanian, Northwest Germany.

—— *pura* Hofker, **269,** p. 327, text fig. 16. Upper Lower Campanian, Northwest Germany.

—— (*Praeglobotruncana*) *renzi* Thalmann-Gandolfi subsp. *primitiva* Küpper, **340,** p. 43, pl. 8, fig. 2. Upper Cenomanian, California, U.S.A. (Note: Preoccupied by *Globotruncana ventricosa primitiva* Dalbiez, 1955, see Homonyma 1956.)

GLOBOTRUNCANININAE Hofker, **269,** p. 318. New subfamily of the family Marginolamellidae Hofker, 1956, *ut infra.* Includes the following genera: *Thalmanninella* Sigal, 1948; *Rotalipora* Brotzen, 1942; *Globotruncana* Cushman, 1927, and *Marginotruncana* Hofker, 1956, *ut infra.*

Globulina lacrima Reuss var. *canadensis* Mellon & Wall, **406,** p. 16, pl. 2, fig. 6. Middle Albian, Western Canada.

Glomospira charoides (Jones & Parker) var. *leroyi* Said & Kenawy, **507,** p. 120, pl. 1, fig. 6. Danian, Sinai, Egypt.

—— *monogranula* Ireland, **285,** p. 847, text fig. 4, nrs. 11–14. Pennsylvanian, Kansas, U.S.A.

Gümbelina midwayensis Cushman var. *nammalensis* Haque, **238,** p. 119, pl. 17, figs. 17–21. Upper Paleocene, Pakistan.

Guttulina caudriae Petters & Sarmiento, **452,** p. 28, pl. 1, fig. 1. Upper Oligocene, Colombia. Synonym: *Guttulina irregularis* (Orbigny) in

Renz, 1948, Geol. Soc. America, Mem. 32, pl. 6, fig. 1.

—— *obesa* Marie, **392,** p. B-245, pl. 3, figs. 3,4. Upper Cretaceous, Belgium.

—— *palmerae* McLean, **405,** p. 333, pl. 40, figs. 4–7,13. Miocene, Virginia, U.S.A.

—— *pseudocostulata* McLean, **405,** p. 334, pl. 40, figs. 8,10,11. Miocene, Virginia, U.S.A.

—— *pyramido-costata* Marie, **392,** p. B-246, pl. 3, fig. 5. Upper Maastrichtian, Belgium.

Guttulina (*Sigmoidina*) *pacifica* (Cushman & Ozawa) var. *ishizaki* Chang, **94,** p. 8, pl. 4, figs. 11–16. Miocene, western Taiwan.

Gyroidina girardana (Reuss), var. *limbata* Haque, **238,** p. 151, pl. 27, fig. 3. Lower Eocene, Pakistan. (Note: Preoccupied by *Gyroidina limbata* Hussey, 1949, see Homonyma 1956.)

—— *keenani* (Cushman & Kleinpell) var. *murietta* Pierce, **457,** p. 1305, pl. 140, fig. 10. Upper Miocene, California, U.S.A.

—— *laciniata* Franzenau, **187,** p. 219, pl. 1, figs. 46–48. Tortonian, Austria.

—— *reussi* Said & Kenawy, **507,** p. 149, pl. 5, fig. 10. Danian, Sinai, Egypt. Synonym: *Gyroidina nitida* (Reuss) in Cushman, 1946, U. S. Geol. Surv. Prof. Pap. 206, p. 140, pl. 58, fig. 5.

Gyroidinoides frizzelli Said & Kenawy, **507,** p. 149, pl. 5, fig. 13. Paleocene, Sinai, Egypt.

—— *voluptus* Haynes, **244,** p. 93, pl. 17, fig. 4; pl. 18, fig. 1. Thanetian, East Kent, England.

Halkyardia minima (Liebus) var. *indica* Tewari, **573,** p. 174, text figs. 5–9. Lutetian, western India.

Haplophragmella tulica Ganelina, **194,** p. 73, pl. 2, figs. 6,7. Visean, Moscow Basin, USSR.

Haplophragmoides formosum Bolin, **65,** p. 287, pl. 37, figs. 7–9. Cenomanian, Minnesota, U.S.A.

—— *jalamensis* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 49, pl. 5, fig. 4. Middle Miocene, Tschokrak, Azerbaidzhan, USSR.

—— *kiewensis* Kaptarenko-Chernoussova, **298,** p. 36, pl. 1, fig. 10. Eocene, Ukrainia, USSR.

—— *multiplum* Stelck & Wall, **549,** p. 37, pl. 4, figs. 14–16. Middle Albian, western Canada.

—— *postis* Stelck & Wall, **549,** p. 38, pl. 4, figs. 23,24. Middle Albian, western Canada.

—— *rudis* Bolin, **65,** p. 285, pl. 37, figs. 3–6. Cenomanian, Minnesota, U.S.A.

—— *spissum* Stelck & Wall, **549,** p. 39, pl. 4, figs. 27,28. Middle Albian, western Canada.

— *sluzari* Mellon & Wall, **486,** p. 17, pl. 1, fig. 15. Middle Albian, western Canada.

Haysakaina ? kawadai Igo, **280,** p. 173, pl. 27, figs. 2–7,7–11,17–20; text fig. 2. Lower Permian, Japan.

Hemicristellaria gotoensis Asano, **23,** p. 11, pl. 3, fig. 8. Recent, south off Goto Island, Japan, 152 m deep.

—— *hanzawai* Asano, **23,** p. 10, pl. 3, fig. 4. Recent, Ariake Bay, Japan, 110 m. depth.

—— *tosaensis* Asano, **23,** p. 11, pl. 3, fig. 5. Recent, Tosa Bay, Japan, 223 m. depth.

—— *tsushimaensis* Asano, **23,** p. 11, pl. 4, fig. 8. Recent, off Shima Peninsula, Japan, depth of 11.6 m.

Hemigordius longus Grozdilova, **229,** p. 524, pl. 1, figs. 3,4. Upper Artinskian, western Urals, USSR.

—— *nalivkini* Grozdilova, **229,** p. 525, pl. 1, fig. 6. Upper Artinskian, western Urals, USSR.

—— *ovatus* Grozdilova, **229,** p. 526, pl. 1, fig. 5. Upper Artinskian, western Urals, USSR.

—— —— —— var. *minima* Grozdilova, **229,** p. 527, pl. 1, fig. 7. Upper Artinskian, western Urals, USSR.

—— *permicus* Grozdilova, **229,** p. 525, pl. 1, fig. 9 Upper Artinskian, western Urals, USSR.

Heterillina tongriensis Gullentops, **323,** p. 14, pl. 1, fig. 10. Lower Tongrian, Belgium.

Heterostomella gracilis Hofker, **275,** p. 64, text fig. 4. Maastrichtian, Germany.

HISTORBITOIDES Brönnimann, **76,** p. 61. New genus of the superfamily Orbitoididae, family Pseudorbitoididae. Maastrichtian. Genotype: *Historbitoides kozaryi* Brönnimann, 1956, *ut infra.*

—— *kozaryi* Brönnimann, **76,** p. 61, pl. 13, figs. 1–11; text figs. 1–7. Maastrichtian, Cuba.

HOLLANDINA Haynes, **244,** p. 94. New genus of the family Discorbidae, subfamily Anomalininae. Thanetian. Genotype: *Hollandina pegwellensis* Haynes, 1956, *ut infra.*

—— *pegwellensis* Haynes, **244,** p. 94, pl. 17, fig. 5. Thanetian, East Kent, England.

Hopkinsina acuto-costata Hagn, **234,** p. 151, pl. 13, fig. 13. Ledian, Italy. Synonym: *Uvigerina eocaena* Gümbel in Cushman & Edwards, 1937, Cushman Lab. Foram. Research, Contr., p. 54, pl. 8, figs. 1,2; and in Hagn, 1954, N. Jahrb. Geol. Paläont., Abhandl., v. 98, p. 419, pl. 26, fig. 10.

—— *citae* Hagn, **234,** p. 152, pl. 13, Ledian, Italy.

—— *franzenaui* Majzon, **187,** p. 213, pl. 1, figs. 34,35. Lower Pannonian, Hungary.

HYALOVIRGULINIDAE Hofker, **273,** p. 45. New family including the genera: *Stainforthia* Hofker, 1956, *ut infra.; Virgulopsis* Finlay, 1939; *Bitubulogenerina* Howe, 1934; *Reussella* Galloway, 1933; *Praeglobobulimina* Hofker, 1951; *Protoglobobulimina* Hofker, 1951, and *Globobulimina* Cushman, 1927. (Note: In Hofker's publication No. 271 of the same year the genera *Globobulimina, Stainforthia,* and *Protoglobobulimina* are assigned to the new family Globobuliminidae, *ut supra.*)

ILLIGATA Bykova, **85,** p. 21. New genus of the family Lagenidae. Lower Silurian. Genotype: *Illigata annae* Bykova, 1956, *ut infra.*

—— *annae* Bykova, **85,** p. 22, pl. 5, figs. 1–5. Lower Silurian, Baltic States.

—— *mensis* Bykova, **85,** p. 22, pl. 4, figs. 6,7. Lower Silurian, Baltic States.

Kathina nammalensis Smout & Hague, **544,** p. 56, pl. 11, figs. 7–9. Paleocene, Salt Range, Pakistan.

KLUBOVELLA, Lebedeva, **350,** p. 52. New genus of familia incerta. Lower Tournaisian. Genotype: *Klubovella konensis* Lebedeva, 1956, *ut infra.*

—— *konensis* Lebedeva, **350,** p. 52, pl. 3, figs. 5,6. Lower Tournaisian, Tengizskaya depression, USSR.

Lagena adjivilensis Pobedina, Voroshilova, Ry-

bina & Kuznetsova, **460,** p. 82, pl. 9, fig. 13. Middle Miocene, Azerbaidzhan, USSR.

—— *aranea* Bykova, **85,** p. 14, pl. 2, figs. 2,3. Middle Ordovician, Baltic States, USSR.

—— *castrensis* Schwager subsp. *transversostriata* Colom, **116,** p. 67, pl. 10, fig. 6. Burdigalian, Mallorca, Spain.

—— *dorseyae* McLean, **405,** p. 330, pl. 39, fig. 8. Miocene, Virginia, U.S.A. Synonym: *Lagena D* Dorsey, 1948, Maryland Geol. Dept., Bull. 2, p. 291, pl. 30, figs. 19–21 (non figs. 22,23).

—— *globulohispida* McLean, **405,** p. 330, pl. 39, fig. 8. Miocene, Virginia, U.S.A. Synonym: *Lagena* sp. *E.* Dorsey, 1948, Maryland Geol. Dept., Bull. 2, p. 291, pl. 31, fig. 24.

—— *glomerosa* Bykova, **85,** p. 16, pl. 3, fig. 2. Lower Silurian, Baltic States, USSR.

—— *luxa* Bykova, **85,** p. 17, pl. 3, figs. 3,4. Lower Silurian, Baltic States. Synonym: *Lagena globosa* Montagu in Brady, 1888, Geol. Magaz., v. 5, n.s. No. 11, p. 481, pl. 13, figs. 1–3. Silurian.

—— *montuirensis* Colom, **116,** p. 71, pl. 10, figs. 1,2. Burdigalian, Mallorca, Spain.

—— *panucella* Bykova, **85,** p. 19, pl. 3, figs. 7,8. Lower Silurian, Baltic States.

—— *palmerae* McLean, **405,** p. 352, pl. 39, figs. 5,6. Miocene, Virginia, U.S.A.

—— *pressula* Bykova, **85,** p. 15, pl. 2, figs. 4–8. Middle Ordovician, Baltic States.

—— *pseudocuticosta* Franzenau & Majzon, **187,** p. 216, pl. 1, fig. 24. Tortonian, Yugoslavia.

—— *pseudohispida* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 82, pl. 9, fig. 14. Middle Miocene, Azerbaidzhan, USSR.

—— *pseudosulcata* McLean, **405,** p. 332, pl. 39, fig. 11. Miocene, Virginia, U.S.A.

—— *reticulo-striata* Haque, **238,** p. 101, pl. 8, fig. 8; pl. 23, figs. 4,5. Upper Paleocene, Pakistan.

—— *subamphora* Asano, **23,** p. 38, pl. 5, figs. 23–25. Recent, Wasaka Bay, 201 m., Japan.

—— *sulcata* Williamson var. *georgiana* Artchvadze in Djanelidze, **150,** p. 101, pl. 1, fig. 10. Upper Miocene, Georgia, USSR.

—— *sulcatiformis* Pozaryska & Urbanek, **471,** p. 115, text fig. 6. Maastrichtian, Poland.

—— *thatae* Djanelidze, **150,** p. 102, pl. 1, fig. 5. Upper Miocene, Georgia, USSR.

—— *tuberosa* Bykova, **85,** p. 18, pl. 3, fig. 6. Lower Silurian, Baltic States. (Note: Preoccupied by *Lagena tuberosa* Matthes, 1939, see Homonyma 1956.)

—— *ventricosa* Bykova, **85,** p. 17, pl. 3, fig. 5. Lower Silurian, Baltic States. Synonym: *Lagena sulcata* Walker & Jacob in Brady, 1888, Geol. Magaz., v. 5, no. 11, p. 481, pl. 13, fig. 11. Silurian. (Note: Preoccupied by *Lagena ventricosa* Silvestri, 1903, see Homonyma 1956.)

Lagena (*Entosolenia ?*) *carteri* McLean, **405,** p. 330, pl. 39, fig. 13. Miocene, Virginia, U.S.A. Synonym: *Lagena* cf. *marginato-perforata* Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 32, pl. 5, fig. 5; and same species in Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Pap. 175-A, p. 17, pl. 5, fig. 15.

—— (——?) —— —— forma *alpha* McLean, **405,** p. 330, pl. 39, fig. 9. Miocene, Virginia, U.S.A.

Lagena (*Reussoolina*) *burdigalensis* Colom, **116,** p. 72, pl. 25, figs. 7–9. Burdigalian, Mallorca, Spain.

Lagenonodosaria sinaensis Said & Kenawy, **507,** p. 137, pl. 3, fig. 15. Paleocene, Sinai, Egypt.

LAMARCKELLA Kaptarenko-Chernoussova, **300,** p. 54. New genus of the family Epistominidae. Aalenian to Bathonian. Genotype: *Lamarckella media* Kaptarenko-Chernoussova, 1956, *ut infra.*

—— *antiqua* Kaptarenko-Chernoussova, **300,** p. 59, pl. 1, fig. 4. Aalenian, USSR.

—— *epistominoides* Kaptarenko-Chernoussova, **300,** p. 59, pl. 1, fig. 10. Upper Bajocian, USSR.

—— *incrasata* Kaptarenko-Chernoussova, **300,** p. 59, pl. 1, fig. 28. Middle Bajocian, USSR.

—— *inflecta* Kaptarenko-Chernoussova, **300,** p. 59, pl. 1, fig. 5. Aalenian, USSR.

—— *media* Kaptarenko-Chernoussova, **300,** p. 59, pl. 1, fig. 8. Middle Bajocian, USSR.

—— *perforata* Kaptarenko-Chernoussova, **300,** p. 59, pl. 1, fig. 12. Lower Bajocian, USSR.

—— *perlucens* Kaptarenko-Chernoussova, **300,** p. 59, pl. 1, fig. 21. Lower Bajocian, USSR.

—— *plana* Kaptarenko-Chernoussova, **300,** p. 59, pl. 1, fig. 9. Middle Bajocian, USSR.

—— *quadrilobata* Kaptarenko-Chernoussova, **300,** p. 59, pl. 1, fig. 7. Aalenian, USSR.

Lamarckina discorbisi Kaptarenko-Chernoussova, **300,** p. 59, pl. 1, fig. 3. Aalenian, USSR.

—— *elongata* Hofker, **273,** p. 104, pl. 12, figs. 18,19; pl. 13, figs. 1–4. Albian. No locality given.

—— *lamellosa* Kaptarenko-Chernoussova, **300,** p. 59, pl. 1, fig. 6. Middle Bajocian, USSR.

—— *prima* Kaptarenko-Chernoussova, **300,** p. 59, pl. 1, fig. 2. Aalenian, USSR.

LASIODISCIDAE Reitlinger, **487,** p. 74. New family including the genera *Howchinia* Cushman, 1927; *Eolasiodiscus* Reitlinger, 1956, *ut supra; Lasiodiscus* Reichel, 1955; and probably also *Monotaxinoides* Brazhnikova & Yarzeva, 1956, *ut infra.*

Lenticulina bayrocki Mellon & Wall, **406,** p. 19, pl. 2, figs. 7,8. Middle Albian, western Canada.

Lepidocyclina ecuadorensis Hofker, **271,** p. 938, text figs. 71–73. Late middle Eocene, Ecuador. Synonym: *Lepidocyclina peruviana* Cushman var., in Shepard, 1937, Geol. of S.W. Ecuador, p. 170, pl. 117, fig. 4.

Lepidocyclina (*Nephrolepidina*) *sumatrensis* (Brady) var. *taptiensis* Rao & Singh, **479,** p. 73, pl. 5, figs. 2,3,5,6; text figs. 1,4,6. Burdigalian, western India.

Lepidorbitoides socialis Papp, **444,** p. 137, text fig. 1, nr. 5. Maastrichtian, Austria. [Note: Preoccupied by *Lepidorbitoides socialis* (Leymerie, 1851), see Homonyma 1956.]

Lingulina paucicostata Chang, **95,** p. 65, pl. 1, figs. 1–6. Miocene, Taiwan.

Loxostomum adrianae Longinelli, **367,** p. 162, pl. 12, figs. 4,5. Calabrian, Italy.

—— *tavani* Longinelli, **367,** p. 162, pl. 12, fig. 3. Calabrian, Italy.

—— *wilsoni* McLean, **405,** p. 348, pl. 45, fig. 5. Miocene, Virginia, U.S.A.

MARGINOLAMELLIDAE Hofker, **269,** p. 313. New family with the following genera: *Globorotalia* Cushman, 1927; *Cancris* Montfort 1808; *Thalmanninella* Sigal, 1948; *Rotalipora* Brotzen, 1942; *Globotruncana* Cushman, 1927; *Marginotruncana* Hofker, 1956, *ut infra,* and *Pararotalia* Y. LeCalvez, 1949. (Note: Introduced as a new family by Hofker in 1951, Siboga-Exped. Monogr. 4a. Foram. pt. 3, p. 485.)

MARGINOTRUNCANA Hofker, **269,** p. 319. New genus of the family Marginolamellidae, subfamily Globotruncaninae. Cenomanian to Maastrichtian. Genotype. *Rosalina marginata* Reuss, 1854 (non Reuss, 1846), Denkschr. k.k. Akad. Wiss. Wien, ser. 1, v. 7, p. 69, pl. 26, fig. 1.

—— *pauperata* Hofker, **269,** p. 331, text figs. 21, 22. Middle and upper Maastrichtian, northwestern Germany. Synonym: *Globotruncana marginata* (Reuss) in Visser, 1950, Proefschr. (Thesis) Leiden, p. 286, pl. 8, fig. 3.

—— *paraventricosa* Hofker, **269,** p. 328, text figs. 2,3,17,18. Middle lower Campanian to middle upper Campanian, northwestern Germany. Synonyma: *Globotruncana ventricosa* White in Brotzen, 1936, Sverig. Geol. Undersög., ser. C, No. 396, p. 171, pl. 13, fig. 4; text fig. 63; and *Globigerina marginata* Reuss in Heron-Allen & Earland, 1910, Jour. Roy. Microsc. Soc., p. 424, pl. 9, figs. 1–3.

Marginulina balearica Colom, **116,** p. 59, pl. 8, fig. 23. Burdigalian, Mallorca, Spain.

—— *binisalemensis* Colom, **116,** p. 60, pl. 8, figs. 30–35. Burdigalian, Mallorca, Sprin.

—— *glabra* Orbigny var. *nammalensis* Haque, **238,** p. 75, pl. 11, figs. 1–4 (non fig. 9). Lower Eocene, Pakistan.

Marginulinopsis capistranoensis W. R. White, **617,** p. 246, pl. 27, figs. 2,3,6. Lower Pliocene, California, U.S.A.

—— *collinsi* Mellon & Wall, **406,** p. 20, pl. 2, figs. 1,2. Middle Albian, western Canada.

—— *deserti* Said & Kenawy, **507,** p. 132, pl. 2, fig. 23. Maastrichtian, Sinai, Egypt.

Marssonella oxycona (Reuss) var. *nammalensis* Haque, **238,** p. 50, pl. 3, fig. 4. Paleocene to Lower Eocene, Pakistan.

—— *traubi* Hagn, **234,** p. 118, pl. 9, fig. 20; text figs. 5, 6. Ledian, Italy. Synonymy: *Textulariella cretosa* Cushman in Cita, 1950, Riv. Ital. Paleont. Strat., v. 56, p. 88, pl. 6, fig. 14.

Massilina quadrans Cushman and Ponton var. *carteri* McLean, **405,** p. 325, pl. 37, fig. 6. Miocene, Virginia, U.S.A.

MICHAILOVELLA Ganelina, 1956, (original publication not available to compiler). New genus of the family Endothyridae, subfamily Endothyrinae. Upper Lower Carboniferous. Genotype: *Endothyrina* (?) *gracilis* Rauser-Chernoussova, 1948, Trudy Inst. Geol. Nauk, Akad. Nauk SSSR., geol. ser. No. 19, p. 163, pl. 3, figs. 8,9. (Cited from: Reitlinger, 1958, Akad. Nauk. SSSR., Voprosy Mikropal., v. 2, p. 57.)

—— *mica* Ganelina, **194,** p. 102, pl. 8, fig. 4. Visean, Moscow Basin, USSR.

Miliammina sproulei Nauss var. *gigantea* Mellon & Wall, **406,** p. 21, pl. 1, fig. 1. Middle Albian, western Canada.

—— *subelliptica* Mellon & Wall, **406,** p. 22, pl. 1, fig. 6. Middle Albian, western Canada.

Miliola pseudoprisca Gullentops, **232,** p. 13, pl. 1, fig. 8. Lower Tongrian, Belgium.

Miliolina articulinoides Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 117, pl. 13, fig. 7. Lower and Middle Sarmatian, USSR.

—— *bejukdusica* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 116, pl. 13, fig. 6. Lower and Middle Sarmatian, Azerbaidzhan, USSR.

—— *corrugis* Kolesnikova & Gerke in Pobedina et al., **460,** p. 113, pl. 12, fig. 4. Middle Sarmatian, Azerbaidzhan, USSR. (Note: Same species already introduced as new by Bogdanowicz, 1952.)

—— *gidjakensis* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 164, pl. 24, fig. 2. Maeotian, Azerbaidzhan, USSR.

—— *pseudovoloshinovae* Pobedina, Voroshilova, Rybina & Kutznesova, **460,** p. 112, pl. 12, fig. 3. Middle Sarmatian, Azerbaidzhan, USSR.

—— *quadrilonga* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 165, pl. 24, fig. 4. Maeotian, Azerbaidzhan, USSR.

—— *reussi* Bogdanowicz var. *azerbaidjana* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 110, pl. 11, fig. 6. Lower Sarmatian, Azerbaidzhan, USSR.

—— —— —— var. *talischensis* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 109, pl. 11, figs. 4,5. Lower Sarmatian, Azerbaidzhan, USSR.

—— *rotunda* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 117, pl. 3, fig. 8. Sarmatian, Azerbaidzhan, USSR. (Note: Preoccupied by *Miliolina akneriana rotunda* Gherke, 1938, see Homonyma 1956.)

—— *simplex* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 165, pl. 24, fig. 3. Maeotian, Azerbaidzhan, USSR.

Misellina compacta Chen, **100,** p. 52, pl. 4, figs. 9–11. Upper Permian, China.

MONODIEXODINA Sosnina, **312,** p. 24. New genus of the family Fusulinidae. Upper Permian. Genotype: *Schwagerina wanneri* (Schubert) var. *sutchanica* Dutkevitch, 1935. Atlas of Leading Forms of Fossil Faunas, v. 6, Permian, p. 39, pl. 3, figs. 4,5.

MONOTAXINOIDES Brazhnikova & Yarzeva **75,** p. 65. New genus of the family Endothyridae, subfamily Tetrataxinae. Carboniferous. Genotype: *Monotaxinoides transitorius* Brazhnikova & Yarzeva, 1956, *ut infra.*

—— *priscus* Brazhnikova & Yarzeva, **75,** p. 65, pl. 1, figs. 4,6. Carboniferous, USSR.

—— *transitorius* Brashnikova & Yarzeva, **75,** p. 65, pl. 1, figs. 2,3,5,8. Carboniferous, USSR.

Monotaxis declivis Ganelina, **194,** p. 82, pl. 5, fig. 2. Visean, Moscow Basin, USSR.

—— *subconica* Brazhnikova & Yarzeva, **75,** p. 63, pl. 1, figs. 13,14,16. Carboniferous, USSR.

—— *subplana* Brazhnikova & Yarzeva. **75,** p. 64, pl. 1, figs. 9,10,11. Carboniferous, USSR.

NEOARCHAEDISCUS Miklukho-Maklaj, **312,**

p. 11. New genus of the family Archaediscidae. Upper Visean to Namurian. Genotype: *Archaediscus incertus* Grozdilova & Lebedeva, 1954, Trudy Vses. Neft. Naucho. Issledov. Geol.-razved. Inst., n.s., v. 81, p. 60, pl. 7, figs. 14,15. Middle Carboniferous, USSR.

Neobulimina abchasiensis Djanelidze, **150,** p. 112, pl. 3, fig. 8. Miocene, Georgia, USSR.

Neoflabellina postreticulata Hofker, **275,** p. 65, text fig. 13. Maastrichtian, Germany.

Neoschwagerina fujimotoi Yamagiwa, **627,** p. 239, pl. 34, figs. 11–15. Permian, Japan.

—— *leei* Chen, **100,** p. 61, pl. 11, figs. 1–6. Upper Permian, China.

—— *sakaguchii* Yamagiwa, **627,** p. 237, pl. 34, figs. 5–10,17. Permian, Japan.

Nephrolepidina see *Lepidocyclina*

NEZZAZATA Omara, **435,** p. 887. New genus belonging possibly to the family Rotaliidae. Cenomanian. Genotype: *Nezzazata simplex* Omara, 1956, *ut infra.*

—— *simplex* Omara, **435,** p. 889, pl. 102, figs. 7–13; text fig. 6. Cenomanian, Sinai, Egypt.

Nodogenerina spinosa Hofker, **275,** p. 69, text fig. 26. Maastrichtian, Germany.

Nodosarella balearica Colom, **116,** p. 107, pl. 20, figs. 4,5. Burdigalian, Mallorca, Spain.

—— *minuta* Said & Kenawy, **507,** p. 145, pl. 4, fig. 30. Paleocene, Sinai, Egypt.

—— *misrensis* Said & Kenawy, **507,** p. 146, pl. 4, fig. 29. Maastrichtian, Sinai, Egypt.

Nodosaria bischgonensis Mamontova, **387,** p. 23, pl. 2, fig. 2. Upper Liassic, northwestern Caucasus, USSR.

—— *contorta* Franzenau, **187,** p. 215, pl. 1, figs. 27,28. Rupelian, Hungary. (Note: Preoccupied by *Nodosaria contorta* Costa, 1856, see Homonyma 1956.)

—— *nammalensis* Haque, **238,** p. 86, pl. 5, fig. 13, pl. 13, figs. 1,2,5. Upper Paleocene, Pakistan.

—— *subquadrata* Sosnina, **312,** p. 16, pl. 2, fig. 1. Upper Permian, USSR.

Nodosaria (?) mediana Bykova, **85,** p. 20, pl. 4, figs. 3–5. Lower Silurian, Baltic States. Synonym: *Lagena clavata* Brady, 1888, Geol. Magaz., v. 5, dec. 3, p. 481, pl. 13, fig. 4.

Nonion agdarensis Khalilov, **305,** p. 11, pl. 2, figs. 1,2. Upper Eocene, Azerbaidzhan, USSR.

—— *alexanderi* Artchvadze in Djanelidze, **150,** p. 107, pl. 1, figs. 16,17. Miocene, Georgia, USSR.

—— *anulatum* Khalilov, **305,** p. 10, pl. 1, figs. 9,10. Upper Eocene, Azerbaidzhan, USSR.

—— —— —— var. *striata* Khalilov, **305,** p. 10, pl. 1, fig. 11. Upper Eocene, Azerbaidzhan, USSR.

—— *asterius* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 79, pl. 9, fig. 6. Middle and Upper Miocene, Azerbaidzhan, USSR.

—— *boueanum* Orbigny var. *zeivensis* Khalilov, **305,** p. 21, pl. 3, fig. 7. Upper Eocene, Azerbaidzhan, USSR.

—— *chanlarensis* Khalilov, **305,** p. 21, pl. 3, fig. 6. Upper Eocene, Azerbaidzhan, USSR.

—— *cuneatum* Khalilov, **305,** p. 23, pl. 3, fig. 9. Upper Eocene, Azerbaidzhan, USSR.

—— *davidi* Artchvadze in Djanelidze, **150,** p. 107, pl. 2, fig. 7. Miocene, Georgia, USSR.

—— *directilineum* Khalilov, **305,** p. 22, pl., 3, fig. 8. Upper Eocene, Azerbaidzhan, USSR.

—— *dosularensis* Khalilov, **305,** p. 23, pl. 4, fig. 1. Lower Oligocene, Azerbaidzhan, USSR.

—— *echinatus* Djanelidze, **150,** p. 105, pl. 2, fig. 2. Upper Miocene, Georgia, USSR.

—— *graniferus* (Terquem) var. *miocenicus* Artchvadze in Djanelidze, **150,** p. 108, pl. 2, fig. 9. Miocene, Georgia, USSR. (Note: Preoccupied by *Nonion miocenicus* Pobedina, Voroshilova, Rybina & Kuznetsova, 1956, *ut infra.*, see Homonyma 1956.)

—— *insolitum* Khalilov, **305,** p. 14, pl. 2, fig. 7. Upper Eocene-Lower Oligocene, Azerbaidzhan, USSR.

—— —— —— var. *major* Khalilov, **305,** p. 15, pl. 2, fig. 8. Upper Eocene, Azerbaidzhan, USSR.

—— *latoseptum* Khalilov, **305,** p. 9, pl. 1, figs. 7,8. Upper Eocene, Azerbaidzhan, USSR.

—— *lucidus* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 130, pl. 18, fig. 6. Lower and Middle Sarmatian, Azerbaidzhan, USSR.

—— *maragaensis* Khalilov, **305,** p. 12, pl. 2, fig. 3. Lower Oligocene, Azerbaidzhan, USSR.

—— *miocenicus* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 129, pl. 18, fig. 5. Sarmatian and Maeotian, Azerbaidzhan, USSR. (Note: Without knowing the date of publication it is not possible to state whether this species is a homonym of *Nonion graniferus miocenicus* Artchvadze, 1956, *ut supra*, or *vice versa.*)

—— *nizami* Khalilov, **305,** p. 19, pl. 3, figs. 2,3. Eocene-Oligocene, Azerbaidzhan, USSR.

—— *nizamiformis* Khalilov, **305,** p. 19, pl. 3, fig. 4. Upper Eocene, Azerbaidzhan, USSR.

—— *oligothalamium* Khalilov, **305,** p. 7, pl. 1, figs. 3,4. Upper Eocene, Azerbaidzhan, USSR.

—— —— —— var. *indjatschajensis* Khalilov, **305,** p. 7, pl. 1, fig. 1. Upper Eocene, Azerbaidzhan, USSR.

—— *ovatum* Khalilov, **305,** p. 18, pl. 3, fig. 1. Upper Eocene, Azerbaidzhan, USSR.

—— *polymorphus* Bogdanowicz in Djanelidze, **150,** p. 106, pl. 3, fig. 6. Upper Miocene, Georgia, USSR.

—— *pricaspicus* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 131, pl. 18, figs. 8,9. Upper Sarmatian, Azerbaidzhan, USSR.

—— *pulleniformis* Khalilov, **305,** p. 16, pl. 2, fig. 14. Upper Eocene, Azerbaidzhan, USSR.

—— —— —— var. *fistulosa* Khalilov, **305,** p. 17, pl. 2, fig. 15. Upper Eocene, Azerbaidzhan, USSR.

—— —— —— var. *sera* Khalilov, **305,** p. 18, pl. 2, fig. 16. Upper Eocene, Azerbaidzhan, USSR.

—— *reculverensis* Haynes, **244,** p. 86, pl. 16, fig. 4. Thanetian, East Kent, England.

—— *rotulum* Khalilov, **305,** p. 6, pl. 1, fig. 1. Upper Eocene, Azerbaidzhan, USSR.

—— —— —— var. *pastera* Khalilov, **305,** p. 8, pl. 1, fig. 5. Upper Eocene, Azerbaidzhan, USSR.

—— *sagittum* Khalilov, **305,** p. 20, pl. 3, fig. 5. Upper Eocene, Azerbaidzhan, USSR.
—— *sakaraulensis* Djanelidze, **105,** p. 104, pl. 2, fig. 1. Upper Miocene, Georgia, USSR.
—— *subinsolitum* Khalilov, **305,** p. 13, pl. 2, fig. 6. Upper Eocene, Azerbaidzhan, USSR.
—— *subrotulum* Khalilov, **305,** p. 9, pl. 1, fig. 6. Lower Oligocene, Azerbaidzhan, USSR.
—— *svandripschi* Artchvadze in Djanelidze, **150,** p. 180, pl. 1, fig. 15. Miocene, Georgia,USSR.
—— *vulgaris* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 129, pl. 18, fig. 4. Sarmatian, Azerbaidzhan, USSR.
Nonion (?) perebedilicus Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 130, pl. 18, fig. 7. Upper Sarmatian, Azerbaidzhan, USSR.
Nonionella cretacea Cushman var. *nammalensis* Haque, **238,** p. 116, pl. 33, fig. 3. Paleocene, Pakistan.
—— *davanaensis* Pierce, **457,** p. 1303, pl. 137, fig. 10. Upper Miocene, California, U.S.A.
—— *excavata* (Orbigny) var. *nammalensis* Haque, **238,** p. 116, pl. 6, figs. 2,5,8. Paleocene, Pakistan. (Note: Preoccupied by *Nonionella cretacea* Cushman var. *nammalensis* Haque, 1956, *ut supra,* see Homonyma 1956.)
—— *jacksonensis* Cushman var. *minuta* Haque, **238,** p. 116, pl. 33, fig. 3. Paleocene, Pakistan.
—— *lakiensis* Haque, **238,** p. 118, pl. 29, fig. 3. Upper Paleocene, Pakistan.
—— *robusta* Plummer var. *perdita* Haynes, **244,** p. 83, pl. 16, fig. 5; pl. 18, fig. 5. Thanetian, East Kent, England.
Nummoloculina heimi Bonet, **72,** p. 16, pl. 3, figs. 3 and 4. Albian-Cenomanian, Eastern Mexico. Synonyma: *Nummoloculina* sp. Leupold, 1940, Eclog. geol. Helv., v. 33, p. 324, text. fig. 5; *Nummoloculina* sp. Bonet, 1952, Bol. Asoc. Mexic. Geol. Petrol., v. 4, p. 181, text-figs. 24,25, 27,28; and *Nummoloculina* sp. Conkin & Conkin, 1956, Bull. Amer. Assoc. Petr. Geol., v. 40, p. 890, text fig. 3.
Nummulites hyalina Hofker, **275,** p. 933, text figs. 64,65. Upper Eocene, Ecuador.
—— *karamani* Dizer, **149,** p. 3, pl. 1, figs. 1–5. Ypresian, Turkey.
Oketaella lenensis Thompson, Verville & Lokke, **577,** p. 798, pl. 89, figs. 1–5. Desmoinesian, Oklahoma, U.S.A.
—— *oscurensis* Thompson, Verville, & Lokke, **577,** p. 799, pl. 89, figs. 6–11. Missourian, New Mexico, U.S.A.
Oolina reussi Said & Kenawy, **507,** p. 145, pl.7 fig. 15. Maastrichtian, Sinai, Egypt.
Orbignyna laffittei Marie, **392,** p. B-235, pl. 1, fig. 7. Upper Campanian, Belgium.
Orbulina cornwallisi McLean, **405,** p. 365, pl. 53, fig. 3. Miocene, Virginia, U.S.A.
ORNATANOMALINA Haque, **238,** p. 196. New genus of the family Anomalinidae. Paleocene. Genotype: *Ornatanomalina geei* Haque, 1956, *ut infra.*
—— *acuta* Haque, **238,** p. 201, pl. 22, fig. 2. Paleocene, Pakistan.
—— *crookshanki* Haque, **238,** p. 198, pl. 18, fig. 10, 1 text fig. Paleocene, Pakistan.
—— —— —— var. *rugosa* Haque, **238,** p. 199 pl. 18, fig. 9. Paleocene, Pakistan.
—— *elegantula* Haque, **238,** p. 201, pl. 18, fig. 3. Paleocene, Pakistan.
—— *geei* Haque, **238,** p. 197, pl. 18, fig. 8. Paleocene, Pakistan.
—— —— —— var. *compressa* Haque, **238,** p. 197, pl. 18, fig. 5. Paleocene, Pakistan.
—— *glaessneri* Haque, **238,** p. 199, pl. 18, figs. 4,11. Paleocene, Pakistan.
—— *hafeezi* Haque, **238,** p. 200, pl. 18, fig. 6. Paleocene, Pakistan.
ORTHELLA Bykova in Kiparisova et al., **312,** p. 19. New genus of the family Miliolidae. Oxfordian. Genotype: *Orthella paalzowi* Bykova, 1956, *ut infra.*
—— *paalzowi* Bykova, **312,** p. 20, pl. 3, figs. 1–12. Upper Oxfordian, Samarskaya Luka, USSR.
Orthomorphina nodulosastriata Colom, **116,** p. 113, pl. 20, figs. 20–24. Burdigalian, Mallorca, Spain.
Ozawainella contrasta Putrya, **476,** p. 384, pl. 3, fig. 12. Middle Carboniferous, Don Basin, USSR.
—— *crassiformis* Putrya, **476,** p. 390, pl. 4, figs. 1–4. Middle Carboniferous, Don Basin, USSR.
—— *hunanensis* Chen, **100,** p. 18, pl. 1, figs. 1–3. Upper Permian, China.
—— *minima* Putrya, **476,** p. 382, pl. 3, figs. 8–10. Middle Carboniferous, Don Basin, USSR.
—— *pseudotingi* Putrya, **476,** p. 385, pl. 3, figs. 13–15. Middle Carboniferous, Don Basin, USSR.
—— *umbonoplicata* Putrya, **476,** p. 390, pl. 3, figs. 19,20. Middle Carboniferous, Don Basin, USSR.
Palaeotextularia angulata Cummings, **134,** p. 219, pl. 1, fig. 4. Namurian, Scotland.
—— *davisella* Cummings, **134,** p. 218. Not figured. Lower Carboniferous. Scotland. Synonym: *Textularia gibbosa* Orbigny in Brady, 1876. Monogr. Carbon. and Permian Foram., p. 131, pl. 10, fig. 26.
—— *eogibbosa* Putrya, **476,** p. 373, pl. 2, fig. 9. Middle Carboniferous, Don Basin, USSR.
PALAEOTEXTULARIIDAE Cummings, **134,** p. 216. New family including the following genera: *Palaeotextularia* Schubert, 1920; *Palaeobigenerina* Galloway, 1933; *Monogenerina* Spandel, 1901; *Deckerella* Cushman & Waters, 1928; *Deckerellina* Reitlinger, 1950; *Cribrostomum* Möller, 1879; *Climacammina* Brady, 1873; *Cribrogenerina* Schubert, 1907.
Palmula woodi Nakkady var. *nammalensis* Haque, **238,** p. 91, pl. 3, fig. 3. Upper Paleocene, Pakistan.
PARAEOFUSULINA Putrya, **476,** p. 458. New subgenus of the genus *Eofusulina* Rauser-Chernoussova, 1951. Middle Carboniferous. Family Fusulinidae, subfamily Fusulininae. Genotype: *Eofusulina triangulifórmis* Putrya, 1956, *ut supra.*
—— see *Eofusulina*
Parafusulina apiculata Knight, **317,** p. 785, pl. 85, figs. 7–10. Permian, Nevada, U.S.A.

—— *communis* Knight, **317,** p. 786, pl. 86, figs. 4–7. Permian, Nevada, U.S.A.
—— *matsubaishi* Fujimoto, **189,** p. 158, pl. 25, figs. 1–10. Permian, Japan.
—— *nakamigawai* Morikawa & Horiguchi, **418,** (paper not available to compiler).
—— *shaksgamensis* Reichel var. *crassimarginata* Knight, **317,** p. 787, pl. 87, figs. 1–3. Permian, Nevada, U.S.A.
—— *sublinearis* Knight, **317,** p. 790, pl. 87, fig. 8; pl. 88, figs. 2,3,6. Permian, Nevada, U.S.A.
—— *superlata* Knight, **317,** p. 790, pl. 88, figs. 1,4. Permian, Nevada, U.S.A.
Paramillerella derbyi Petri, **440,** p. 26, pl. 2, figs. 5–7. Carboniferous, Brazil.
PARAREICHELINA Miklukho-Maklaj, 1956. (Original publication not seen by compiler). New genus of the family Ozawainellidae, subfamily Ozawainellinae. Permian. Cited from: Miklukho-Maklaj, Rauser-Chernoussova & Rozovskaja, 1958, Voprosy Mikropaleont., v. 2, Akad. Nauk SSSR., p. 17. Genotype not known to compiler.
Parschwagerina shengi Chen, **100,** p. 46, pl. 6, figs. 1–4. Upper Permian, China.
Parastaffella candida Ganelina, **194,** p. 118, pl. 12, figs. 9–11. Visean, Moscow Basin, USSR.
—— *grandis* Putrya, **476,** p. 393, pl. 4, fig. 10. Middle Carboniferous, Don Basin, USSR.
—— *luminosa* Ganelina, **194,** p. 119, pl. 12, fig. 12. Visean, Moscow Basin, USSR.
PARRELLOIDES Hofker, **271,** p. 936. New genus of the family Parrelloididae Hofker, 1956, *ut infra.* Geologic range not stated (Tertiary-Recent ?). Genotype: *Cibicides hyalinus* Hofker, 1951, Siboga-Exped., Monogr. 4-A, Foraminifera pt. 3, p. 359, text figs. 244,245. Recent, Indonesia.
PARRELLOIDIDAE Hofker, **271,** p. 936. Includes the genera *Parrelloides* Hofker, 1956, *ut supra; Osangularia* Brotzen, 1940, and *Siphonina* Reuss, 1850.
Patellina elliotti Stelck & Wall, **549,** p. 46, pl. 3, figs. 7–9. Middle Albian, western Canada.
Pellatispira kabyliensis Muraour, **422,** p. 323, pl. 4, figs. 1–4. Lower Oligocene, Kabylia, Algeria.
Pisolina subsphaerica Sheng, **528,** p. 205, pl. 2, fig. 6. Permian, China.
PLANOARCHAEDISCUS Miklukho-Maklaj, in Kiparisova et al., **312,** p. 10. New genus of the family Archaediscidae. Middle Visean to Namurian. Genotype: *Archaediscus spirillinoides* Rauser-Chernoussova, 1948, Akad. Nauk, SSSR., Trudy Inst. Geol. Nauk, v. 62, geol. ser. No. 19, p. 153, pl. 2, figs. 7,8.
PLANOENDOTHYRA Reitlinger, 1956. (Original publication not seen by compiler.) New genus of the family Endothyridae, subfamily Endothyrinae. Middle and Upper Carboniferous. Cited from: Reitlinger, 1958, Akad. Nauk SSSR, Voprosy Mikropal., v. 2, p. 57. (Genotype: *Endothyra aljuvotica* Reitlinger, 1950.)
Planorbulinella khairabadensis Haque, **238,** p. 210, pl. 29, figs. 8,10. Paleocene, Pakistan.
—— *nammalensis* Haque, **238,** p. 211, pl. 19, figs. 1–7,9. Paleocene, Pakistan.
Planularia visserae Marie, **392,** p. B-242, pl. 2, figs. 1,2. Maastrichtian, Belgium.
—— see also *Lenticulina*
Planulina karsteni Petters & Sarmiento, **452,** p. 31, pl. 1, fig. 9. Upper Oligocene, Colombia.
Plectina perturbata Franzenau, **187,** p. 219, pl. 1, figs. 25,26. No age stated; fossil, Hungary.
PLECTINELLA Marie, **392,** p. B-240. New genus of the family Valvulinidae. Campanian to Maastrichtian. Genotype: *Plectinella virgulinoides* Marie, 1956, *ut infra.*
—— *virgulinoides* Marie, **392,** p. 241, pl. 1, figs. 1–4. Maastrichtian, Belgium.
Plectofrondicularia gracilis Smith, **541,** p. 93, pl. 12, figs. 2–5. Oligocene, California, U.S.A.
PLECTOGYRINA Reitlinger, 1956. (Original publication not seen by compiler.) New genus of the family Endothyridae, subfamily Plectogyrinae. Carboniferous. Genotype: *Endothyra (?) fomichaensis* Lebedewa, 1954. Trudy Vses. Neft. Naucho-issledov. geol.-razved. Inst., n.s., v. 81, p. 256, pl. 5, figs. 1–3. Lower Carboniferous, Kuznetsk Basin, USSR. Cited from: Reitlinger, 1958, Akad. Nauk SSSR., Voprosy Mikropaleont., v. 2, p. 57.
PLECTOGYRINAE Reitlinger, 1956. (Original publication not seen by compiler.) New subfamily of the family Endothyridae. Cited from Reitlinger, 1958, Akad. Nauk, SSSR., Voprosy Mikropaleont., v. 2, p. 57. Includes the following genera: *Plectogyra* E. Zeller, 1950; *Plectogyrina* Reitlinger, 1956, *ut supra; Globoendothyra* Reitlinger, 1956, *ut supra; Michailovella* Ganelina, 1956, *ut supra;* and *Endothyranella* Galloway & Harlton, 1930. Geologic range: Lower Carboniferous to upper Permian.
Praeglobotruncana see *Globotruncana*
PRAELAMARCKINA Kaptarenko-Chernoussova, **300,** p. 54. New genus of the family Epistominidae. Aalenian to Lower Callovian. Genotype: *Praelamarckina humilis* Kaptarenko-Chernoussova, 1956, *ut infra.*
—— *humilis* Kaptarenko-Chernoussova, **300,** p. 59, pl. 1, fig. 1. Aalenian, USSR.
Profusulinella acutissima Putrya, **476,** p. 419, pl. 6, figs. 13–15. Middle Carboniferous, Don Basin, USSR.
—— *brevissima* Putrya, **476,** p. 420, pl. 6, figs. 17–19. Middle Carboniferous, Don Basin, USSR.
—— *pseudorhomboides* Putrya & Leontovich, var. *subrefecta* Putrya, **476,** p. 422, not figured. Middle Carboniferous, Don Basin, USSR. Synonym: *Fusulinella rhomboides* Chen, 1934, Mem. Nation. Research Inst., Peiping, Inst. Geol., v. 14, p. 35, pl. 6, fig. 14.
—— *rotundata* Putrya, **476,** p. 413, pl. 6, fig. 20. Middle Carboniferous, Don Basin, USSR.
PROTELPHIDIUM Haynes, **244,** p. 86. New genus of the family Nonionidae. Thanetian. Genotype: *Protelphidium hofkeri* Haynes, 1956, *ut infra.*
—— *hofkeri* Haynes, **244,** p. 86, pl. 16, fig. 9; pl. 18, fig. 3. Thanetian, East Kent, England.
PSEUDOCIBICIDOIDES Ujiié, **593,** p. 263. New genus of the family Anomalinidae. Re-

cent. Genotype: *Pseudocibicidoides katasensis* Ujiié, 1956, *ut infra.*

—— *katasensis* Ujiié, **593,** p. 263, pl. 13, figs. 1–3. Recent, beach sand, Japan.

Pseudoclavulina constans Bandy, **37,** p. 198, pl. 30, fig. 5. Recent, Gulf of Mexico. Synonym: *Pseudoclavulina mexicana* Cushman in Phleger & Parker, 1951, Geol. Soc. America, Mem. 46, pt. 2, pl. 2, figs. 15,16.

—— *pseudoarenata* Said & Kenawy, **507,** p. 125, pl. 1, fig. 33. Maastrichtian, Sinai, Egypt.

—— *pseudohumilis* Haque, **238,** p. 42, pl. 9 fig. 1. Lower Eocene, Pakistan.

Pseudofusulina duplithecata Igo, **283.** (Publication not seen by compiler.)

—— *lativenta* Knight, **317,** p. 784, pl. 85, figs. 2–6. Permian, Nevada, U.S.A.

Pseudogaudryina see *Gaudryina.*

Pseudoglandulina caucasica Mamontova, **387,** p. 28, pl. 1, fig. 7. Upper Liassic, northwestern Caucasus, USSR.

—— *japonica* Asano, **23,** p. 44, text figs. 4,5. Recent, Toyama Bay, Japan.

PSEUDOGLOBOROTALIA Haque, **238,** p. 184. New genus of the family Globorotaliidae. Paleocene. Genotype: *Pseudogloborotalia ranikotensis* Haque, 1956, *ut infra.*

—— *khairabadensis* Haque, **238,** p. 188, pl. 14, fig. 7; pl. 17, fig. 1; pl. 19, figs. 18,19; pl. 27, fig. 5. Paleocene, Pakistan (Note: misspelled "*khiarabadensis.*")

—— *paleocenica* Haque, **238,** p. 187, pl. 17, fig. 1; pl. 19, figs. 20, 21; pl. 36, fig. 6. Paleocene, Pakistan.

—— *ranikotensis* Haque, **238,** p. 185, pl. 19, fig. 1. Paleocene, Pakistan.

—— —— —— var. *oblonga* Haque, **238,** p. 186, pl. 10, fig. 2; pl. 34, fig. 2. Paleocene, Pakistan.

Pseudonodosaria clearwaterensis Mellon & Wall, **406,** p. 23, pl. 2, figs. 15–17. Middle Albian, western Canada.

Pseudoparrella hyalina Hofker, **273,** p. 109, pl. 14, figs. 1–4. No locality or age given.

Pseudopolymorphina calemberti Marie, **392,** p. B-247, pl. 2, figs. 3,4. Maastrichtian, Belgium.

—— *ubaghsi* Marie, **392,** p. B-249, pl. 2, fig. 7. Lower Maastrichtian, Belgium.

Pseudostaffella compressa Rauser-Chernoussova var. *donbassica* Putrya, **476,** p. 398, pl. 5, figs. 4,5. Middle Carboniferous, Don Basin, USSR.

—— *donica* Putrya, **476,** p. 404, pl. 5, figs. 14–16. Middle Carboniferous, Don Basin, USSR.

—— *minutissima* Putrya, **476,** p. 400, pl. 5, fig. 6. Middle Carboniferous, Don Basin, USSR.

—— *primaeva* Putrya, **476,** p. 397, pl. 5, fig. 18. Middle Carboniferous, Don Basin, USSR.

—— *umbilicatula* Putrya, **476,** p. 403, pl. 5, fig. 17. Middle Carboniferous, Don Basin, USSR.

Pseudostaffella ? tamanouchiensis Sakagami, **510,** p. 262, pl. 37, figs. 1–3. Upper Permian, Japan.

PSEUDOSTAFFELLINAE Putrya, **476,** p. 395. New subfamily of the family Staffellidae, with only one genus: *Pseudostaffella* Thompson, 1942.

Pseudouvigerina sinaensis Said & Kenawy, **507,** p. 141, pl. 4, fig. 3. Maastrichtian, Sinai, Egypt.

PSEUDOWOODELLA Haque, **238,** p. 202. New genus of the family Anomalinidae. Paleocene. Genotype: *Pseudowoodella mamilligera* Haque, 1956, *ut infra.*

—— *mamilligera* Haque, **238,** p. 202, pl. 33, fig. 2. Paleocene, Pakistan.

Pullenia platti Haynes, **244,** p. 87, pl. 17, fig. 18. Thanetian, East Kent, England.

PUNJABIA Haque, **238,** p. 152. New genus of the family Rotaliidae. Paleocene. Genotype: *Punjabia ovoidea* Haque, 1956, *ut infra.* (Note: Preoccupied by *Punjabia* Eames, 1952, see Homonyma 1956.)

—— *ovoidea* Haque, **238,** p. 153, pl. 30, fig. 1. Paleocene, Pakistan.

—— *patalaensis* Haque, **238,** p. 154, pl. 34, fig. 1. Paleocene, Pakistan.

Putrella gurovi Putrya, **476,** p. 468, pl. 17, figs. 6,7. Middle Carboniferous, Don Basin, USSR.

Pyrgo pacifica Asano, **23,** p. 79, pl. 9, fig. 24. Recent, off Tanegashima, Japan, 516 m.

Quadrimorphina albertensis Mellon & Wall, **406,** p. 24, pl. 2, figs. 12–14. Middle Albian, western Canada.

Quasiendothyra adducta Ganelina, **194,** p. 84, pl. 5, figs. 7–9. Visean, Moscow Basin, USSR.

—— *fucosa* Ganelina, **194,** p. 85, pl. 5, figs. 5,6. Visean, Moscow Basin, USSR.

—— *paradoxa* Lebedeva, **350,** p. 51, pl. 3, fig. 2. Lower Tournaisian, Tengizskaya depression, USSR.

—— *smekhovi* Lebedeva, **350,** p. 50, pl. 2, fig. 7. Lower Tournaisian, Tengizskaya depression, USSR.

Quinqueloculina gapperi Haque, **238,** p. 54, pl. 32, fig. 11. Upper Paleocene, Pakistan.

—— *grosserugosa* Gullentops, **232,** p. 10, pl. 1, fig. 2. Lower Tongrian, Belgium.

—— *lamarckiana* Orbigny var. *inflata* Haque, **238,** p. 55, pl. 32, fig. 3. Paleocene, Pakistan.

—— *pseudovata* Haque, **238,** p. 56, pl. 25, fig. 1. Paleocene, Pakistan.

—— *ranikotensis* Haque, **238,** p. 53, pl. 21, fig. 5; pl. 32, fig. 12. Paleocene, Pakistan.

—— *seminulangulata* McLean, **405,** p. 322, pl. 37, fig. 8. Miocene, Virginia, U.S.A. Synonym: *Quinqueloculina venusta ?* Cushman, 1918 U. S. Geol. Surv. Bull. 676, p. 70, pl. 29, fig. 3.

—— *trevisani* Longinelli, **367,** p. 115, pl. 4, fig. 2. Calabrian, Italy.

—— *triloculiniforma* McLean, **405,** p. 322, pl. 37, figs. 9–11. Miocene, Virginia, U.S.A.

—— *wheeldoni* McLean, **405,** p. 323, pl. 37, fig. 13. Miocene, Virginia, U.S.A.

RABANITINA Smout, **543,** p. 343. New genus of the family Ceratobuliminidae. Cenomanian. Genotype: *Rabanitina basraensis* Smout, 1956, *ut infra.*

—— *basraensis* Smout, **343,** p. 344, pl. 1, fig. 32; pl. 2, figs. 7–22; text fig. 2. Cenomanian, Iraq.

Rauserella fujimotoi Kobayashi, **321,** p. 266, pl. 32, figs. 1–7. Permian, Japan.

RECTOBULIMINA Marie, **392,** p. B-249. New genus of the family Buliminidae, subfamily Virgulininae. Maastrichtian. Genotype: *Rectobulimina carpentierae* Marie, 1956, *ut infra.*

—— *carpentierae* Marie, **392,** p. B-250, pl. 3, figs. 1,2. Maastrichtian, Belgium.

RECTOCIBICIDELLA McLean, **405,** p. 370.

New genus of the family Anomalinidae. Miocene. Genotype: *Rectocibicidella robertsi* McLean, 1956, *ut infra*.

—— *robertsi* McLean, **405,** p. 370, pl. 49, figs. 12,13. Miocene, Virginia, U.S.A.

Rectocornuspira compta Ganelina, **194,** p. 66, pl. 1, figs. 4,5. Visean, Moscow Basin, USSR.

—— *diffusa* Ganelina, **194,** p. 69, pl. 2, fig. 3. Visean, Moscow Basin, USSR.

—— *dilucida* Ganelina, **194,** p. 68, pl. 1, fig. 8. Visean, Moscow Basin, USSR.

—— *diserta* Ganelina, **194,** p. 69, pl. 2, figs. 1,2. Visean, Moscow Basin, USSR.

—— *prolixa* Ganelina, **194,** p. 67, pl. 1, figs. 6,7. Visean, Moscow Basin, USSR.

Rectocornuspira (*?*) *insolentis* Ganelina, **194,** p. 70, pl. 2, figs. 4,5. Visean, Moscow Basin.

Rectoeponides dubia Haque, **238,** p. 154, pl. 6, fig. 6. Upper Paleocene, Pakistan.

Rectoglandulina bulla Said & Kenawy, **507,** p. 134, pl. 3, fig. 10. Paleocene, Sinai, Egypt.

Rectogümbelina longa, Said & Kenawy, **507,** p. 139, pl. 3, fig. 35. Danian, Sinai, Egypt.

Rectuvigerina advena Said & Kenawy, **507,** p. 144, pl. 4, fig. 24. Lower Paleocene, Sinai, Egypt.

REOPHACELLA Kaptarenko-Chernoussova, **298,** p. 32. New genus of the family Reophacidae. Eocene. Genotype: *Reophacella compressa* Kaptarenko-Chernoussova, 1956, *ut infra*.

—— *compressa* Kaptarenko-Chernoussova, **298,** p. 32, pl. 3, fig. 13. Eocene, Ukrainia, USSR.

Reussella mortensi Hofker, **273,** p. 51, pl. 5, figs. 1,4–7. Recent, West Indies.

—— *triquetra* Franzenau, **187,** p. 215, pl. 1, figs. 31–33. Rupelian, Hungary.

—— *weberi* Hofker, **273,** undescribed. Pl. 5, fig. 3. Recent, West Indies. (Note: Preoccupied by *Reusella weberi* Hofker, 1951, see Homonyma 1956.)

REUSSOOLINA Colom, **116,** p. 72. New subgenus of *Lagena* Walker & Jacob, 1888. Family Lagenidae. Upper Cretaceous to Recent. Subgenotype: *Oolina apiculata* Reuss, 1851, Haidinger's Naturwiss. Abhandl. 4, p. 22, pl. 1, fig. 1. Upper Cretaceous, Poland.

—— see *Lagena*

Robulus anceps Franzenau, **187,** p. 215, pl. 1, figs. 29,30. Rupelian, Hungary.

—— *benacensis* Hagn, **234,** p. 129, pl. 11, fig. 5, Ledian, Italy.

—— *pseudoiota* McLean, **405,** p. 325, pl. 38, figs. 2,4. Miocene, Virginia, U.S.A. Synonyma: *Robulus iota* Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 25, pl. 4, fig. 1; same species in Cushman & Ponton, 1932, loc. cit., p. 58; same species in Cushman & Cahill, 1933, U. S. Geol. Surv. Prof. Pap. 175-A, p. 12, pl. 4, fig. 1; and same species in Puri, 1953, Florida Geol. Surv. Bull. 36, p. 97, pl. 29, figs. 1,2.

—— *reussi* Haque, **238,** p. 66, pl. 28, fig. 4; text fig. 1. Upper Paleocene, Pakistan. Synonym: *Cristellaria* (*Robulina*) *nitida* Orbigny in Reuss, 1863, Sitzber. k. Akad. Wiss. Wien. math.-naturwiss. Cl., Abt. 1, p. 54, pl. 6, fig. 66.

—— *taluensis* Chang, **94,** p. 7, pl. 4, figs. 7–10. Miocene, western Taiwan.

Rosalina mimiconcinna Haynes, **244,** p. 91, pl. 16, fig. 13. Thanetian, East Kent, England.

Rotalia darderi Colom, **116,** p. 81, pl. 15, figs 1–3. Burdigalian, Mallorca, Spain.

—— *hensoni* Smout var. *daviesinoides* Smout & Haque, **544,** p. 55, pl. 11, fig. 11. Paleocene, Salt Ranges, Pakistan.

—— *limbatobeccarii* McLean, **405,** p. 357, pl. 47, figs. 5–8, Miocene, Virginia, U.S.A.

Rotaliella roscoffensis Grell, **223,** p. 760, text fig. 2, No locality and age given.

Rotorbinella basilica Bandy, **37,** p. 199, pl. 31, fig. 3. Recent, off west coast of Florida, 23 fathoms.

RUBRATELLA Grell, **223,** p. 760. Family not stated. New genus. Genotype: *Rubratella intermedia* Grell, 1956, *ut infra*. Recent.

—— *intermedia* Grell, **223,** p. 760, text fig. 3. No age and locality given.

SACCAMMINOIDES Ireland, **285,** p. 841. New genus of the family Astrorhizidae, subfamily Saccammininae. Pennsylvanian. Genotype: *Saccamminoides multicellus* Ireland, 1956, *ut infra*. (Note: Preoccupied by *Saccamminoides* Geroch, 1955, see Homonyma 1956.)

—— *multicellus* Ireland, **285,** p. 841, text fig. 3, nr. 2. Pennsylvanian, Kansas, U.S.A.

SAKHIELLA Haque, **238,** p. 155. New genus of the family Rotaliidae. Paleocene. Genotype: *Sakhiella nammalensis* Haque, 1956, *ut infra*.

—— *nammalensis* Haque, **238,** p. 156, pl. 10, fig. 1. Paleocene, Pakistan.

Samarina calceus Ganelina, **194,** p. 104, pl. 10, fig. 3. Visean, Moscow Basin, USSR.

—— *minuscularia* Ganelina, **194,** p. 103, pl. 9, figs. 3,4. Visean, Moscow Basin, USSR.

—— *orbiculata* Ganelina, **194,** p. 105, pl. 10, fig. 4. Visean, Moscow Basin, USSR.

—— *rovnensis* Ganelina, **194,** p. 104, pl. 10, fig. 5. Visean, Moscow Basin, USSR.

Saracenaria projectura Stelck & Wall, **549,** p. 50, pl. 3, figs. 22–25. Middle Albian, western Canada.

—— *trollopei* Mellon and Wall, **406,** p. 25, pl. 2, figs. 26,27. Middle Albian, western Canada.

Schenckiella fragilis Hofker, **271,** p. 896, text fig. 2. Upper Eocene, Ecuador.

Schubertella elliptica Putrya, **476,** p. 411, pl. 6, fig. 10. Middle Carboniferous, Don Basin, USSR.

Schwagerina brevipola Chen, **100,** p. 32, pl. 5, figs. 4–7. Upper Permian, China.

—— *chinensis* Chen, **100,** p. 35, pl. 5, fig. 10. Upper Permian, China.

—— *furoni* Thompson var. *tamanouchiensis* Sakagami, **510,** p. 262, pl. 37, figs. 4–12. Upper Permian, Japan.

—— *henbesti* Chen, **100,** p. 24, pl. 1, figs. 19–21. Upper Permian, China.

—— *hunania* Chen, **100,** p. 35, pl. 3, figs. 11–13. Upper Permian, China.

—— *hupehensis* Chen, **100,** p. 38, pl. 8, figs. 1–3. Upper Permian, China.

—— *kwangehiensis* Chen, **100,** p. 23, pl. 1, figs. 17,18. Upper Permian, China.

—— *liangshanensis* Sheng, **528,** p. 212, pl. 7, figs. 7,8. Permian, China.

—— *lingyunensis* Chen, **100,** p. 31, pl. 3, figs. 8–10. Upper Permian, China.
—— *longipertica* Chen, **100,** p. 27, pl. 2, figs. 7, 8 Upper Permian, China.
—— *longitermina* Chen, **100,** p. 37, pl. 4, figs. 4–6. Upper Permian, China.
—— *medullaris* Knight, **317,** p. 781, pl. 83, figs. 11,12. Permian, Nevada, U.S.A.
—— *megalocula* Chen, **100,** p. 27, pl. 2, fig. 12. Upper Permian, China.
—— *mengi* Chen, **100,** p. 31, pl. 5, figs. 1–3. Upper Permian, China.
—— *moormanensis* Knight, **317,** p. 781, pl. 84, figs. 4,5. Permian, Nevada, U.S.A.
—— *mucronata* Knight, **317,** p. 782, pl. 84, figs. 6,7. Permian, Nevada, U.S.A.
—— *multialveola* Chen **100,** p. 33, pl. 5, fig. 8. Upper Permian, China. (Note: This species is also published as new in Sheng, **528,** p. 213, pl. 7, figs. 9,10, Permian, China.)
—— *pactiruga* Chen, **100,** p. 39, pl. 8, figs. 4,5. Upper Permian, China. (Note: Also published as new species in Sheng, **528,** p. 211, pl. 8, figs. 7,8. Permian, China).
—— *paralpina* Chen, **100,** p. 26, pl. 2, figs. 9–11. Upper Permian, China.
—— *pseudocompta* Sheng, **528,** p. 214, pl. 8, figs. 4–6. Permian, China.
—— *quasifosteri* Sheng, **528,** p. 215, pl. 2, figs. 5,7–10. Permian China.
—— *retusa* Knight, **317,** p. 783, pl. 84, figs. 10, 11. Permian, Nevada, U.S.A.
—— *salopeki* Kochansky-Devidé, **322,**, p. 21, pl. 5, fig. 1–8. Uralian, Croatia, Yugoslavia.
—— *skinneri* Chen, **100,** p. 29, pl. 2, figs. 13–15. Upper Permian, China.
—— *subinflata* Knight, **317,** p. 783, pl. 84, figs. 8, 9. Permian, Nevada, U.S.A.
—— *suni* Chen, **100,** p. 34, pl. 5, fig. 9. Upper Permian, China.
—— *tienchiaensis* Chen, **100,** p. 30, pl. 3, fig. 1. Upper Permian, China.
—— *tieni* Chen, **100,** p. 23, pl. 1, figs. 13–16. Upper Permian, China.
—— *wuhsuehensis* Chen, **100,** p. 25, pl. 2, figs. 4–6. Upper Permian, China.
—— *yüi* Chen, **100,** p. 28, pl. 2, fig. 19. Upper Permian, China.
—— *yunnanensis* Chen, **100,** p. 36, pl. 4, figs. 1–3. Upper Permian, China.

SEMITEXTULARIIDAE Pokorny, **465,** p. 284. New family including the following genera: *Semitectularia* Miller & Carmer, 1933; *Pseudopalmula* Cushman & Stainbrook, 1943, and *Paratextularia* Pokorny, 1951. Geologic range of family: Middle to upper Devonian (Givetian to Fammenian).

Semivulvulina see *Spiroplectammina*

Sigmoidina see *Guttulina*

Sigmoilina asselberghsi Gullentops, **232,** p. 12, pl. 1, fig. 6. Lower Tongrian, Belgium.
—— *ecuadorensis* Hofker, **271,** p. 900, text fig. 9. Upper Middle Eocene, Ecuador.
—— *tschokrakensis* Gerke var. *kobistanensis* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 45, pl. 4, fig. 4. Middle Miocene, Tschokrak, Azerbaidzhan, USSR.

SILICOPLACENTINA Kovary, **330,** p. 266. (Original publication not seen by compiler). New genus of Thecamoebina testacea (but possibly a foraminifer?). Pannonien. Genotype: *Silicoplacentina hungarica* Kovary, 1956.
—— *hungarica* Kovary, **330.** (Original publication not seen by compiler).

Siphogaudryina see *Gaudryina.*

Siphonina primitiva Hofker, **273,** p. 120, pl. 15, figs. 19–24. Recent, West Indies.

Sphaeroidina (?) dubia Haque, **238,** p. 173, pl. 14, fig. 9, pl. 15, figs. 9,10. Paleocene, Pakistan.

SPIROBOLIVINA Hofker, **271,** p. 915. New genus of the family Bolivinidae. Upper Eocene. Genotype: *Bolivinopsis pulchella* Cushman & Stainforth, 1947, Cushman Lab. Foram. Research, Contr., v. 23, p. 78, pl. 17, figs. 4,5. Upper Eocene, Ecuador.

Spiroloculina elegantissima Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 46, pl. 4, fig. 5. Middle Miocene, Azerbaidzhan, USSR. (Note: Preoccupied by *Spiroloculina elegantissima* Said, 1949, see Homonyma 1956.)
—— *plana* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 47, pl. 4, fig. 7. Middle Miocene, Azerbaidzhan, USSR. (Note: Preoccupied by *Spiroloculina plana* Matouschek, 1894, see Homonyma 1956.)

Spiroplectammina paracarinata Said & Kenawy, **507,** p. 122, pl. 1, fig. 13. Danian, Sinai, Egypt.
—— *taiwanica* Chang, **96,** p. 67, pl. 1, figs. 1–11. Upper Miocene, Taiwan.

Spiroplectammina (*Semivulvulina*) *gümbeli* Hagn, **234,** p. 114, pl. 9, figs. 12,13. Ledian, Italy. (For synonymy consult original publication.)

STAINFORTHIA Hofker, **271,** p. 908. New genus of the family Globobuliminidae. Upper Eocene and Recent. Genotype: *Virgulina concava* Höglund, 1947, Uppsala Zool. Bidrag. v. 26, p. 257, pl. 23, figs. 3,4; pl. 32, figs. 4–7; text figs. 273–275. Recent, Skagerak, Sweden. (Note: Also cited by Hofker, **273,** p. 46, as a new genus and placed here in the family Hyalovirgulinidae, *ut supra.*)
—— *dalliformis* Hofker, **271,** p. 908, text fig. 21. Upper Eocene, Ecuador. Synonym: *Loxostomum dalli* Cushman & Stainforth, 1951, Jour. Paleontology, v. 25, p. 155, pl. 26, fig. 58.

Stensiöina altissima Hofker, **274,** p. B-214, text fig. 31. Contact Maastrichtian-Campanian, Belgium and southern Holland.
—— *granosa* Haque, **238,** p. 156, pl. 10, fig. 1. Paleocene, Pakistan.

Stichocibicides moravicus Pokorny, **463,** p. 272, text figs. 11–15. Uppermost Eocene, Czechoslovaquia.

Stomatorbina acarinata Pokorny, **463,** p. 268, text figs. 9,10. Uppermost Eocene, Czechoslovaquia.
——*ranikotensis* Haque, **238,** p. 157, pl. 8, fig. 2. Paleocene, Pakistan.

SVRATKINA Pokorny, **463,** p. 257. New genus of the family Discorbidae, subfamily Discorbinae. Upper Eocene. Genotype: *Discorbis tuberculata* (Balkwill & Wright) var. *australiensis* Chapman, Parr & Collins, 1934, Jour. Linn.

Soc. London, Zool., v. 38, No. 262, p. 563, pl. 8, fig. 9.

TAPPANINA Montanaro Gallitelli, **420,** p. 36. New genus of the family Heterohelicidae, subfamily Bolivinitinae. Upper Cretaceous. Genotype: *Bolivinita selmaensis* Cushman, 1933, Cushman Lab. Foram. Research, Contr., v. 9, p. 58, pl. 7, figs. 3,4. Upper Cretaceous, Tennessee, U.S.A.

Tetrataxis conciliatus Ganelina, **194,** p. 83, pl. 5, fig. 1. Visean, Moscow Basin, USSR.

—— *donetzica* Putrya, **476,** p. 376, pl. 2, figs. 5,6. Middle Carboniferous, Don Basin, USSR.

—— *eomaxima* Putrya, **476,** p. 376, pl. 2, figs. 1,2. Middle Carboniferous, Don Basin, USSR.

—— *zelleri* Petri, **449,** p. 23, text fig. 1, Carboniferous, Amazon Basin, Brazil (misspelled: "*Tetrataxys*").

Textularia bella Kaptarenko-Chernoussova, **298,** p. 50, pl. 2, fig. 20. Eocene, Ukrainia, USSR.

——*bucheri* Ireland, **285,** p. 859, text fig. 7, nrs. 1,2. Pennsylvanian, Kansas, U.S.A.

—— *crookshanki* Haque, **238,** p. 32, pl. 9, fig. 9. Paleocene, Pakistan.

—— *elsiae* Ireland, **285,** p. 859, text fig. 7, nrs. 3–5. Pennsylvanian, Kansas, U.S.A.

—— *eustisensis* McLean, **405,** p. 318, pl. 35, fig. 5. Miocene, Virginia, U.S.A.

—— *flexibilis* Kaptarenko-Chernoussova, **298,** p. 48, pl. 2, figs. 14,15,18. Eocene, Ukrainia, USSR.

—— *minuta* Kaptarenko-Chernoussova, **298,** p. 50, pl. 2, fig. 23. Eocene, Ukrainia, USSR. (Note: Preoccupied by *Textilaria minuta* Terquem, 1882, see Homonyma 1956.)

—— *pseudobliqua* McLean, **405,** p. 320, pl. 35, figs. 8,9; pl. 36, fig. 17. Miocene, Virginia, U.S.A.

—— —— —— subsp. *aspera* McLean, **405,** p. 320, pl. 36, figs. 8,14. Miocene, Virginia, U.S.A. (Note: Preoccupied by *Textularia aspera* Ehrenberg, 1838, see Homonyma 1956.)

—— *punjabensis* Haque, **238,** p. 31, pl. 9, fig. 12. Upper Paleocene, Pakistan.

—— *virgilensis* Ireland, **285,** p. 861, text fig. 7, nrs. 10–14. Pennsylvanian, Kansas, U.S.A.

Textularioides (?) carteri McLean, **405,** p. 321, pl. 35, fig. 12. Miocene, Virginia, U.S.A.

Thalmanninella wicheri Hofker, **269,** p. 322, text figs. 4,5. Lower Turonian, Germany.

Thomasinella aegyptia Omara, **435,** p. 885, pl. 101, figs. 1–6; text fig. 1. Cenomanian, Sinai, Egypt.

—— *fragmentaria* Omara, **435,** p. 886, pl. 101, fig. 11. Cenomanian, Sinai, Egypt.

Thurammina lawrencensis Ireland, **285,** p. 843, text fig. 3, nr. 10. Pennsylvanian, Kansas, U.S.A.

—— *rectangularis* Ireland, **285,** p. 843, text fig. 3, nr. 8, Pennsylvanian, Kansas, U.S.A.

—— *verrucosa* Ireland, **285,** p. 843, text fig. 3, nr. 9. Pennsylvanian, Kansas, U.S.A.

Tolypammina extenda Ireland, **285,** p. 849, text fig. 4, nrs. 23,24. Pennsylvanian, Kansas, U.S.A.

—— *nodosa* Ireland, **285,** p. 850, text fig. 4, nrs. 25–29. Pennsylvanian, Kansas, U.S.A.

—— *polyverta* Ireland, **285,** p. 850, text fig. 4, nrs. 30–35. Pennsylvanian, Kansas, U.S.A.

—— *rugosa* Ireland, **285,** p. 851, text fig. 5, nrs. 1,2. Pennsylvanian, Kansas, U.S.A.

—— *serpens* Ireland, **285,** p. 851, text fig. 5, nrs. 3–5. Pennsylvanian, Kansas, U.S.A.

TORIYAMAIA Kanmera, **295,** p. 251. New genus of the family Fusulinidae. Lower Permian. Genotype: *Toriyamaia laxiseptata* Kanmera, 1956, *ut infra.*

—— *laxiseptata* Kanmera, **295,** p. 252, pl. 36, figs. 1–14. Lower Permian, Japan.

TRACHELINELLA Montanaro Gallitelli, **420,** p. 38. New genus of the family Heterohelicidae, subfamily Bolivinitinae. Upper Cretaceous. Genotype: *Bolivina watersi* Cushman, 1927, Cushman Lab. Foram. Research. Contr., v. 2, p. 88, pl. 12, fig. 6. Upper Cretaceous, Texas.

Trifarina see *Angulogerina.*

Triloculina bellatula Bandy, **37,** p. 198, pl. 29, fig. 11. Recent, off west coast of Florida, U.S.A. 28 feet depth.

—— *linneiana* Orbigny var. *comis* Bandy, **37,** p. 198, pl. 29, fig. 12. Recent, off west coast of Florida, U.S.A., 42 feet depth.

—— *sarahae* Haque, **238,** p. 59, pl. 32, figs. 5–10. Paleocene, Pakistan.

—— *tongriensis* Gullentops, **232,** p. 15, pl. 1, fig. 12. Lower Tongrian, Belgium. Synonym: *Triloculina* cf. *consobrina* Orbigny in Bhatia, 1955, Jour. Paleontology, v. 29, p. 675, pl. 67, fig. 16.

Triplasia inaequalis Hagn, **234,** p. 112. Not figured. Ledian, Italy. Synonymy: *Frankeina* sp. *A* Israelsky, 1951, U. S. Geol. Surv. Prof. Pap. 240-A, p. 12, pl. 3, figs. 5–8; and *Triplasia species* Loeblich & Tappan, 1952, Smithson. Miscell. Coll., v. 118, No. 15, p. 42, pl. 7, fig. 12.

Tritaxia athabascensis Mellon & Wall, **406,** p. 27, pl. 1, figs. 16, 17. Middle Albian, western Canada.

—— *barakai* Said & Kenawy, **507,** p. 123, pl. 1, fig. 18. Maastrichtian, Sinai, Egypt.

Tritaxilina maxima Salvatori, **512,** p. 35, text. figs. 1–3. Oligocene, Italy.

Triticites brevispina Kochansky-Devidé, **322,** p. 19, pl. 4, figs. 1–6. Uralian, Croatia, Yugoslavia.

—— *winterensis* Thompson, Verville & Lokke, **577,** p. 807, pl. 93, figs. 1–13. Missourian, Iowa, U.S.A.

Trochammina gatesensis Stelck & Wall, **549,** p. 53, pl. 4, figs. 9–11. Middle Albian, western Canada.

—— *globosa* Bolin, **65,** p. 289, pl. 38, figs. 8,9; text figs. 5–7. Cenomanian, Minnesota, U.S.A. (Note: *cave Trochammina globulosa* Cushman, 1920).

—— *mcmurrayensis* Mellon & Wall, **406,** p. 28, pl. 1, figs. 2–5. Middle Albian, western Canada.

—— *minnesotensis* Bolin, **65,** p. 289, pl. 38, fig. 7; text figs. 5–8. Cenomanian, Minnesota, U.S.A.

Turrispirillina caucasica Mamontova, **387,** p. 36, pl. 1, fig. 15, Upper Liassic, northwestern Caucasus.

Uvigerina codazzii Petters & Sarmiento, **452,** p. 30, pl. 1, fig. 4. Lower Oligocene, Colombia.
—— *gallowayi* Cushman var. *basiquadrata* Petters & Sarmiento, **452,** p. 30, pl. 1, fig. 5. Upper Oligocene, Colombia. Synonymy: *Uvigerina gallowayi* Cushman in Bermudez, 1949, Cushman Lab. Foram. Research, Spec. Publ. 25, p. 204, pl. 13, fig. 7.
—— *gianninii* Longinelli, **367,** p. 164, pl. 13, fig. 23. Calabrian, Italy.
—— *gracilissima* Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 81, pl. 9, fig. 10. Middle Miocene, Azerbaidzhan, USSR.
—— *kernensis* Barbat & Estorff var. *subcalva* W. R. White, **617,** p. 259, pl. 32, fig. 6, Lower Pliocene, California, U.S.A. Synonymy: *Uvigerina kernensis* Barbat & Estorff in Cushman & McCulloch, 1948, Allan Hancock Pacific Exped., v. 6, p. 261, pl. 33, fig. 5.
—— *lakiensis* Haque, **238,** p. 137, pl. 29, figs. 1,2. Upper Paleocene, Pakistan.
—— *porqueroensis* Petters & Sarmiento, **452,** p. 30, pl. 1, fig. 6. Upper Oligocene, Colombia.
—— *redmondi* Petters & Sarmiento, **452,** p. 30, pl. 1, fig. 7. Upper Oligocene, Colombia.
—— *rothwelli* Pierce, **457,** p. 1303, pl. 139, fig. 3, Upper Miocene, California, U.S.A.
—— *senticosa* Cushman var. *adiposa* W. R. White, **617,** p. 259, pl. 32, fig. 9. Lower Pliocene, California, U.S.A.
—— *subproboscidea* Haque, **238,** p. 136, pl. 27, fig. 8. Upper Paleocene, Pakistan.
Uvigerinella (?) konkensis Pobedina, Voroshilova, Rybina & Kuznetsova, **460,** p. 81, pl. 9, fig. 11. Middle Miocene, Azerbaidzhan, USSR.
USSURIELLA Sosnina in Kiparisova et al., **312,** p. 21. New genus of the family Fusulinidae. Upper Permian. Genotype: *Ussuriella ussurica* Sosnina, 1956, *ut infra.*
—— *ussurica* Sosnina in Kiparisova et al., **312,** p. 22, pl. 4, figs. 1–6. Upper Permian, Ussuri region, Far East, Soviet Russia.
Vaginulina longiformis Said & Kenawy, **507,** p. 134, pl. 3, fig. 13. Paleocene, Sinai, Egypt. [Note: Preoccupied by *Vaginulina longiforma* (Plummer, 1926), see Homonyma 1956.]
Valvulina nammalensis Haque, **238,** p. 47, pl. 21, figs. 10, 11. Paleocene, Pakistan.
Valvulineria alicia Pierce, **457,** p. 1306, pl. 141, fig. 3. Upper Miocene, California, U.S.A.
—— *danvillensis* (Howe & Wallace) var. *nammalensis* Haque, **238,** p. 160, pl. 7, fig. 10. Upper Paleocene, Pakistan.
—— *filiae-principis* Hagn, **234,** p. 159, pl. 14, figs. 13,14. Ledian, Italy.
—— *hillsi* Haque, **238,** p. 161, pl. 12, fig. 1. Lower Eocene, Pakistan.
—— *patalensis* Haque, **238,** p. 162, pl. 12, fig. 2. Upper Paleocene to Lower Eocene, Pakistan.
—— *ranikotensis* Haque, **238,** p. 162, pl. 17, fig. 10; pl. 19, fig. 16. Paleocene, Pakistan.
—— *washingtoni* McLean, **405,** p. 354, pl. 47, figs. 3,4. Miocene, Virginia, U.S.A.
Verbeekina crassispira Chen, **100,** p. 49, pl. 9, figs. 7–10. Upper Permian, China.
—— *ellipsoidalis* Chen, **100,** p. 49, pl. 9, figs. 1–4. Upper Permian, China.
Verneuilina aegyptiaca Said & Kenawy, **507,** p. 122, pl. 1, fig. 16. Maastrichtian, Sinai, Egypt.
—— *karreri* Said & Kenawy, **507,** p. 122, pl. 1, fig. 17. Danian, Sinai, Egypt. Synonym: *Verneuilina cretacea* Karrer in Nakkady, 1952, Inst. d'Égypte, Bull. v. 33, p. 405, pl. 3, fig. 1.
—— *laevigata* Haque, **238,** p. 34, pl. 21, figs. 12, 19. Paleocene, Pakistan.
—— *porta* Stelck & Wall, **549,** p. 55, pl. 4, figs. 3,4. Middle Albian, western Canada.
—— *virgilensis* Ireland, **285,** p. 863, fig. 7, nr. 32. Pennsylvanian, Kansas, U.S.A.
VERNEUILINELLA Tairov, **564,** p. 113. New genus of the family Verneuilinidae. Aptian. Genotype: *Verneuilinella azerbaidjanica* Tairov, 1956, *ut infra.*
—— *azerbaidjanica* Tairov, **564,** p. 113, text fig. 1. Lower Aptian, USSR.
Virgulina cylindrica Cushman & Bermudez var. *nagappai* Haque, **238,** p. 131, pl. 20, fig. 6. Upper Paleocene, Pakistan.
—— *dubia* Haque, **238,** p. 129, pl. 20, fig. 9; pl. 25, figs. 3,4. Upper Paleocene, Pakistan.
—— —— —— var. *robusta* Haque, **238,** p. 129, pl. 17, figs. 4,5; text figs. 1–4. Upper Paleocene, Pakistan.
—— *nodosa* Stewart & Stewart var. *nammalensis* Haque, **238,** p. 131, pl. 20, figs. 7,8. Upper Paleocene, Pakistan.
Virgulina zinnae Djanelidze, **150,** p. 113, pl. 3, fig. 9. Miocene, Georgia, USSR.
VIRGULINOPSIS Hofker, **274,** p. 47. New genus of the family Hyalovirgulinidae. No genotype, locality and age given. [Note: Two species are cited as belonging to this new genus: *Virgulinopsis cubana* (Bermudez), p. 47, pl. 4, figs. 8–15, which may possibly be the genotype, and *Virgulinopsis (olim Bolivina) translucens* (Phleger & Parker), p. 48, pl. 4, figs. 16–20; *cave Virgulopsis* Finlay, 1939.]
WANGANELLA Sosnina in Kiparisova, **312,** p. 15. New genus of the family Lagenidae. Upper Permian. Genotype: *Wanganella ussuriensis* Sosnina, 1956, *ut infra.*
—— *ussuriensis* Sosnina, **312,** p. 16, pl. 1, figs. 1–11; pl. 2, figs. 2,3. Upper Permian, Far East, Soviet Russia.
Wedekindellina ardmorensis Thompson, Verville & Lokke, **577,** p. 803, pl. 92, figs. 1–12. Contact Desmoinesian-Missourian, Oklahoma, U.S.A.
WOODELLA Haque, **238,** p. 194. New genus of the family Anomalinidae. Paleocene. Genotype: *Woodella granosa* Haque, 1956, *ut infra.*
—— *granosa* Haque, **238,** p. 195, pl. 18, fig. 2. Paleocene, Pakistan.
—— *nammalensis* Haque, **238,** p. 195, pl. 18, figs. 1,8. Paleocene, Pakistan.
Yabeina proboscis Chen, **100,** p. 66, pl. 13, figs. 8–10. Upper Permian, China.
Yangchienia kwangsiensis Chen, **100,** p. 20, pl. 1, figs. 8–11. Upper Permian, China.

NOMINA NOVA 1956

Globoendothyra pseudoglobulus Reitlinger, 1956, new name for *Endothyra globulus* Möller, 1878, Mém. Acad. Impér. Sci. St. Petersbourg, ser.

7, vol. 15, Nr. 9, p. 98, pl. 4, fig. 4; pl. 13, figs. 1–4; *non Endothyra globulus* Eichwald, 1860, (*olim Nonionina globulus*). Lethaea Rossica, v. 1, p. 350, pl. 22, fig. 17. Lower Carboniferous.

Lagena alcocki W. R. White, **617,** p. 246, pl. 27, fig. 7. Lower Pliocene, California, U.S.A., New name for *Entosolenia williamsoni* Alcock, 1865, Lit. Phil. Soc. Manchester, Proc., p. 193 (figured as *Lagena williamsoni* in Wright, 1877, Belfast Field Natur. Club, Proc., Appendix 4, p. 104, pl. 4, fig. 14); *non Lagena williamsoni* Harvey & Bailey, 1854, Acad. Nat. Sci. Philadelphia, Proc., v. 6, p. 431, not figured.

—— *biarritzensis* Hagn, **234,** p. 142. Ledian, Italy. New name for *Lagena striato-punctata* Parker & Jones var. *caudata* Halkyard, 1919, Manchester Phil. Lit. Soc., Mem. Proc., v. 62, p. 59, pl. 3, fig. 12; *non Oolina* (*Lagena*) *caudata* Orbigny, 1839, *teste* Reuss, 1862, Sitzber. k. Akad. Wiss. Wien, v. 46, p. 325.

Lenticulina (*Planularia*) *pseudoparallela* E. & I. Seibold, **523,** p. 114, pl. 7, fig. 1; text figs. 3-m, 3-n. Lower Malm, Southern Germany. New name for *Cristellaria parallela* Schwager, 1865 (non Reuss, 1863), Ver. Vaterl. Naturkde. Württemberg, Abhandl., v. 21, p. 121, pl. 5, fig. 5; for *Cristellaria complanata* Schwager in Paalzow, 1922, Naturhist. Ges. Nürnberg, Abhandl., v. 22, p. 24, pl. 2, fig. 28; for *Vaginulina parallela* Reuss in Paalzow, 1932, Ver. Vaterl. Naturkde. Württemberg, v. 88, p. 131, pl. 9, fig. 32; for *Marginulina jurassica* Gümbel in Paalzow, 1932, loc. cit., v. 88, p. 109, pl. 7, fig. 8; and for *Cristellaria* (*Planularia*) *filosa* Terquem in Franke, 1936, Preuss. Geol. Landesanst., Abhandl., N.F. v. 169, p. 95, pl. 9, fig. 25.

Nonion brunatus Hofker, **271,** p. 941, text figs. 75, 76. Upper Eocene, Ecuador. New name for *Planulina chirana* Cushman & Stone, 1947, Cushman Lab. Foram. Research, Spec. Publ. 20, p. 26, pl. 4, fig. 3; and for same species in Cushman & Stainforth, 1951, Jour. Paleontology, v. 25, p. 162, pl. 28, fig. 13.

Nonionella stainforthi Hofker, **271,** p. 942, text fig. 77. Upper Eocene, Ecuador. New name for *Nonion ecuadoranum* Cushman & Stainforth, 1951, Jour. Paleontology, v. 25, p. 149, pl. 26, figs. 19,20.

Rosalina sidebottomi Said & Kamel, **506,** p. 363, pl. 2, fig. 19. Recent, Mediterranean, Egypt. New name for *Discorbis rosacea* Sidebottom, 1908, Manchester Lit. Phil. Soc., Mem. Proc., v. 52, No. 13, p. 12, pl. 4, figs. 3–5.

Spiroloculina colomi Said & Kamel, **506,** p. 354, pl. 1, fig. 34. Recent, Mediterranean, Egypt. New name for *Spiroloculina limbata* Fornasini, 1904, Accad. Sci. Ist. Bologna Mem., ser. 6, v. 1, p. 6, pl. 1, fig. 11; and for *Spiroloculina* cf. *limbata* Colom, 1942, Inst. Español Oceanogr., Notas y Resum., ser. 2, No. 108, p. 27, pl. 6, figs. 118, 119.

Uvigerina bellula Bandy, **37,** p. 199, pl. 31, fig. 13. Recent, off west coast of Florida, U.S.A., depth of 69 fathoms. New name for *Uvigerina auberiana* Orbigny var. *laevis* Goës, 1896, (non *Uvigerina laevis* Ehrenberg, 1845), Mus. Comparat. Zool., Bull., v. 29, p. 51, pl. 4, figs. 71–74.

Valvulineria stainforthi Hofker, **271,** p. 942, text fig. 78. Upper Eocene, Ecuador. New name for *Discorbis samanica* Cushman & Stone, 1947, Cushman Lab. Foram. Research, Spec. Publ. 20, p. 19, pl. 2, fig. 27; and for same species in Cushman & Stainforth, 1951, Jour. Paleontology, v. 25, p. 157, pl. 17, figs. 14,15.

HOMONYMA 1956

ARNOLDIA Hovasse, **279,** p. 2584. Precambrian, Ivory Coast, preoccupied by: *Arnoldia* Mayer, 1887, Geol. Karte d. Schweiz, Beitr., v. 24, pt. 2, p. 27 (Mollusca) (and also by *Arnoldia* Kieffer, 1895 a dipteran, and by *Arnoldia* Wlassenko, 1931, a worm.) (Note: According to Hovasse's letter of January 19, 1959, the author intends to change his homonym to *Birrimarnoldia*).

Bigenerina elongata Ireland, **285,** p. 862, *ut supra,* Preoccupied by *Bigenerina elongata* Gauger, 1953, Utah Geol. Miner. Surv. Bull. 47, p. 59, pl. 6, figs. 3,4, Upper Cretaceous, Wyoming, U.S.A.

Bolivina binaensis Khalilov var. *costata* Khalilov, **306,** p. 211, *ut supra,* preoccupied by *Bolivina costata* Orbigny, 1839, Voyage Amér. Méridion, v. 5, pt. 4, Foraminfera, p. 62, pl. 8, figs. 8,9. Recent, Pacific, off Bolivia.

—— *budensis* (Hantken, 1876) var. *longa* Khalilov, **306,** p. 192, *ut supra,* preoccupied by *Bolivina aduncosutura* Khalilov, 1956, var. *longa* Khalilov, 1956, *ut supra.*

—— *caucasensis* Khalilov, 1956, var. *carinata* Khalilov, **306,** p. 190, *ut supra,* preoccupied by *Bolivina beyrichi* Reuss, 1851, var. *carinata* Hantken, 1875, K. Ungar. Geol. Anst., Mitth. Jahrb., v. 4, p. 64, pl. 7, fig. 12.

—— *compta* Khalilov, 1956, var. *carinata* Khalilov, **306,** p. 212, *ut supra,* preoccupied by *Bolivina beyrichi carinata* Hantken, 1875, loc. cit., p. 64, pl. 7, fig. 12.

—— *concavosuturata* Khalilov, 1956, var. *carinata* Khalilov, **306,** p. 186, *ut supra,* preoccupied by *Bolivina beyrichi carinata* Hantken, 1875, loc. cit., p. 64, pl. 7, fig. 2.

—— *decurrens* (Ehrenberg, 1854) var. *parallela* Said & Kenawy, **507,** p. 143, *ut supra,* preoccupied by *Bolivina* (*olim Textularia*) *parallela* (Perner, 1892), Foram. Ceske Cenoman., p. 54, pl. 9, fig. 13, (*teste:* Cushman, 1932, Cushman Lab. Foram. Research, Contr., v. 8, p. 94). (Note: According to a letter, dated February 24, 1959, the authors intend to change their homonym to *Bolivina decurrens neckhliana* nom. nov.)

—— *dilatata* Reuss, 1850, var. *abbreviata* Longinelli, **367,** p. 156, *ut supra,* preoccupied by *Bolivina limbata* Brady, 1881, var. *abbreviata* Heron-Allen & Earland, 1924, Linn. Soc. London, Jour., v. 35, p. 622, pl. 36, figs. 25–27.

—— *gracilis* Cushman & Applin, 1926, var. *caucasia* Khalilov, **306,** p. 194, *ut supra,* preoccupied by *Bolivina subincrassata* Khalilov, 1956, var. *caucasica* Khalilov, 1956, *ut supra.*

—— *italica* Cushman, 1936, var. *substriata* Longinelli, **367,** p. 158, *ut supra,* preoccupied

by *Bolivina beyrichi* Reuss, 1851, var. *substriata* Reuss in Schlicht, 1870, Foram. Pietzpuhl, pl. 33, figs. 17–19 (and also by *Bolivina substriata* Egger, 1893).

—— *praebinaensis* Khalilov, 1956, var. *carinata* Khalilov, **306,** p. 210, *ut supra*, preoccupied by *Bolivina beyrichi* Reuss, 1851, var. *carinata* Hantken, 1875, K. Ungar. Geol. Landes-Anst., Mitth. Jahrb., v. 4, p. 64, pl. 7, fig. 2.

—— —— —— var. *crassa* Khalilov, **306,** p. 209, *ut supra*, preoccupied by *Bolivina incrassata* Reuss, 1851, var. *crassa* Vassilenko & Mjatliuk, 1947, Vses. Neft. naucho-issledov. geol.-razved. Inst., Trudy, Mikrofauna Caucasus, Emba, Central Asia, p. 203, pl. 2, figs. 3–5.

—— *serrata* Khalilov, **306,** p. 192, *ut supra*, preoccupied by *Bolivina obsoleta* (Eley, 1859) var. *serrata* Wright, 1900, Geol. Magazine, n.s., dec. 4, v. 7, p. 100, pl. 5, fig. 9.

—— —— —— var. *parallela* Khalilov, **306,** p. 193, *ut supra*, preoccupied by *Bolivina parallela* (Perner, 1892, *olim Textularia*), *teste* Cushman, 1932, Contr. Cushman Lab. Foram. Research, v. 8, p. 94.

—— *subincrassata* Khalilov, 1956, var. *costata* Khalilov, **306,** p. 183, *ut supra*, preoccupied by *Bolivina costata* Orbigny, 1839, Voyages Amér. Méridion., v. 5, pt. 4, Foram., p. 62, pl. 8, figs. 8,9.

Cibicides alleni (Plummer) var. *carinata* Haque, **238,** p. 208, *ut supra*, preoccupied by *Cibicides* (*olim Truncatulina*) *carinatus* (Terquem, 1882), *teste:* LeCalvez, 1949, Mém. Explicat. Carte géol. France, p. 45, pl. 4, figs. 72–74. (Note: to be changed to *Cibicides alleni* (Plummer) var. *cristata* nom. nov. by Haque, according to letter, dated March 24, 1959).

—— *multifarius* (Schwager, 1883) var. *limbata* Haque, **238,** p. 205, *ut supra*, preoccupied by *Cibicides suspiratus* Nuttall, 1930, var. *limbatus* Cita, 1950, Riv. Ital. Paleont. Strat., v. 56, p. 102, pl. 9, fig. 7. [Note: to be changed to *Bolivina multifarius* (Schwager) var. *ghalebi* nom. nov. by Haque, according to letter of March 24, 1959.]

Discorbis conicus Djanelidze, **150,** p. 119, *ut supra*, preoccupied by *Discorbis conica* van Bellen, 1945, Proefschr. (Thesis), Utrecht, p. 48, pl. 5, figs. 4–6.

Dorothia textularioides Marie, **392,** p. B-239, *ut supra*, preoccupied by *Dorothia textilarioides* (Hantken, 1876, *olim Gaudryina*), *teste* Cushman, 1937, Spec. Publ. 8, Cushman Lab. Fora. Research, p. 87, pl. 9, figs. 17,18.

Elphidium tumidum (Bogdanowicz) var. *umbilicata* Djalenidze, **150,** p. 111, *ut supra*, preoccupied by *Elphidium umbilicatum* (Orbigny, 1826, *olim Polystomella*), *teste* Fornasini, 1905, Mem. Accad. Sci. Ist. Bologna, ser. 6, v. 1, p. 13, pl. 3, fig. 11.

—— *venustus* Pobedina, et al., **460,** p. 128, *ut supra*, preoccupied by *Elphidium venustum* (Schultze, 1854, *olim Polystomella*), Organismus Polythalam., p. 67, pl. 6, figs. 7–9.

Entosolenia ornata (Terquem & Terquem) var. *compressa* Longinelli, **367,** p. 138, *ut supra*, preoccupied by *Entosolenia* (*Lagena*) *compressa* (Orbigny, 1839) *teste* Cushman & Parker, 1938, U. S. Nat. Mus., Proc., v. 80, art. 3, p. 14, pl. 3, fig. 16.

Epistomina limbata Kaptarenko-Chernoussova, **300,** *ut supra*, preoccupied by *Epistomina limbata* Tappan, 1943, Jour. Paleontology, v. 17, p. 512, pl. 82, figs. 13,14.

Gaudryina laevigata Franke, 1914, var. *elongata* Haque, **238,** p. 36, *ut supra*, preoccupied by *Gaudryina ruthenica* Reuss, 1851, var. *elongata* Dunikowski, 1867, Kosmos (Lvov), v. 4, p. 133. [Note: to be changed by Haque, according to letter, dated March 24, 1959, to *Gaudryina laevigata* (Reuss) var. *saadi* nom. nov.]

Globigerina stainforthi Hofker, **271,** p. 955, *ut supra*, preoccupied by *Globigerina stainforthi* Brönnimann, 1952, Bull. Amer. Paleontology, v. 34, No. 143, p. 23, pl. 3, figs. 10–12.

Globotruncana (*Praeglobotruncana*) *renzi* (Thalmann-Gandolfi, 1942) var. *primitiva* Küpper, **340,** p. 43, *ut supra*, preoccupied by *Globotruncana* (*Globotruncana*) *ventricosa* White var. *primitiva* Dalbiez, 1955, Micropaleontology, v. 1, p. 168, text fig. 6. (Note: This varietal homonym of the late Klaus Küpper will be elevated by Thalmann to specific rank and named *Globotruncana küpperi* nom. nov.)

Gyroidina girardana (Reuss, 1865) var. *limbata* Haque, **238,** p. 151, *ut supra*, preoccupied by *Gyroidina limbata* Hussey, 1949, Jour. Paleontology, v. 23, p. 136, pl. 28, figs. 6,7. [Note: to be renamed by Haque, according to letter, dated March 24, 1959: *Gyroidina girardana* (Reuss) var. *sarwari* nom. nov.]

Lagena tuberosa Bykova, **85,** p. 18, *ut supra*, preoccupied by *Lagena tuberosa* Matthes, 1939, Palaeontogr. v. 90, Abt. A, p. 61, pl. 4, fig. 22.

—— *ventricosa* Bykova, **85,** p. 17, *ut supra*, preoccupied by *Lagena ventricosa* Silvestri, 1903, Accad. R. Sci. Torino, Rendic., v. 39, p. 10, text fig. 6.

Lepidorbitoides socialis Papp, **444,** p. 137, *ut supra*, preoccupied by *Lepidorbitoides socialis* (Leymerie, 1851, *olim Orbitolites*) *teste* H. Douvillé, 1920, Soc. géol. France, Bull., ser. 4, v. 20, p. 222.

Miliolina rotunda Pobedina et al., **460,** p. 117, *ut supra*, preoccupied by *Miliolina akneriana* (Orbigny) var. *rotunda* Gherke, 1938, Probl. of Paleont., Moscow, v. 4, p. 296, pl. 1, fig. 1 [Note: *cave Miliolina rotundata* (Montagu, 1803).]

Nodosaria contorta Franzenau, **187,** p. 215, *ut supra*, preoccupied by *Nodosaria contorta* Costa, 1856, Atti, Accad. Pont., v. 7, no. 2, p. 159, pl. 16, fig. 2, and also by Hantken, 1868 and by Clodius, 1922.

Nonion graniferus (Terquem, 1882) var. *miocenicus* Artchvadze, **150,** p. 108, preoccupied by *Nonion miocenicus* Pobedina et al., **460,** p. 129, *ut supra*. (Note: since the date of the publications by Artchvadze in Djanelidze, **150,** and Pobedina et al., **460,** is not known to the compiler it is difficult to decide to whom the homonym has to be ascribed.)

Nonionella excavata (Orbigny) var. *nammalensis* Haque, **238,** p. 116, *ut supra*, preoccupied by

Nonionella cretacea Cushman var. *nammalensis* Haque, **238,** p. 116, *ut supra*. [Note: to be renamed by Haque, according to letter, dated March 24, 1959: *Nonionella excavata* (Orbigny) var. *thalmanni* nom. nov. To the compiler's knowledge there exists no *Nonion* or *Nonionella excavata* erected by d'Orbigny; the author of the species is most probably Seguenza, 1862: see *Nonionina excavata* Seguenza, 1862, Atti Accad. Gioenia Sci. Nat., ser. 2, v. 18, p. 98, pl. 1, fig. 4].

PUNJABIA Haque, **238,** p. 152 *ut supra*, preoccupied by *Punjabia* Eames, 1952, Roy. Soc. London, Phil. Trans., ser. B, v. 236, no. 631, p. 38, a gastropod. Renamed by Haque *CINCORIOLA* nom. nov. 1958, Contr. Cushman Found. Foram. Research, v. 9, p. 103.

Reussella weberi Hofker, **273,** preoccupied by (or conspecific? with) *Reussella weberi* Hofker, 1951 Siboga-Exped. Monogr. 4-A, Foram. pt. 3, p. 170, text figs. 106, 107.

SACCAMMINOIDES Ireland, **285,** p. 841, *ut supra*, preoccupied by *Saccamminoides* Geroch, 1955, Ann. Soc. géol. Pologne, vol. 23, p. 54.

Spiroloculina elegantissima Pobedina et al., **460,** p. 46, *ut supra*, preoccupied by *Spiroloculina elegantissima* Said, 1949, Spec. Publ. 26, Cushman Lab. Foram. Research, p. 15, pl. 1, fig. 41.

—— *plana* Pobedina et al., **460,** p. 47, *ut supra*, preoccupied by *Spiroloculina plana* Matouschek, 1894, Lotos (Prag), n.s. v. 15, p. 124, text fig. 1.

Textularia minuta Kaptarenko-Chernoussova, **300,** p. 50, *ut supra*, preoccupied by *Textilaria minuta* Terquem, 1882, Soc. géol. France, Mém., ser. 3, v. 2, p. 147, pl. 23, fig. 15.

Textularia pseudobliqua McLean, 1956, subsp. *aspera* McLean, **405,** *ut supra*, preoccupied by *Textilaria aspera* Ehrenberg, 1838, Abhandl. k. Akad. Wiss. Berlin, p. 134, pl. 4, figs. 4, 5, gamma. Also preoccupied by Brady, 1884. (Note: according to McLean's letter of March 26, 1959, this homonym will be renamed and elevated to specific rank: *Textularia yorktownensis* nom. nov.)

Vaginulina longiformis Said & Kenawy, **507,** p. 134, *ut supra*, preoccupied by *Cristellaria* (now *Vaginulina*) *longiforma* Plummer, 1926, Univ. Texas Bull. 2644, p. 102, pl. 13, fig. 4. (Note: According to a letter dated February 24, 1959, the authors intend to change their homonym to *Vaginulina giddiana* nom. nov.)

NOMINA NUDA 1956

Until evidence is available that the following name has duly been proposed in accordance with the International Rules of Zoological Nomenclature, it is, for the time being, regarded as a nomen nudum:

Elphidium latusovum Krasheninnikov, 1956, **334,** p. 1, fig. c.

JOURNAL OF PALEONTOLOGY, V. 33, NO. 6, P. 1115–1119, 1 TEXT-FIG., NOVEMBER, 1959

NEW VIRGILIAN AND WOLFCAMPIAN FENESTRATE BRYOZOANS FROM KANSAS

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ABSTRACT—Four new species and one subspecies of the fenestrate bryozoan genus *Penniretepora*, *P. curvula*, *P. flexistriata*, *P. nodocarinata*, *P. nodolineata*, and *P. pustulosa kansasensis*, are described from Virgilian and Wolfcampian rocks of eastern Kansas.

INTRODUCTION

FOUR new species and one subspecies of the little studied fenestrate bryozoan *Penniretepora* are described. This work is the result of statistical studies carried out on Virgilian and Wolfcampian fenestrates of Kansas during 1954 and 1955.

The descriptions are based on the measurement procedure originally recommended by Moore (1929, p. 15, footnote 1) and enlarged upon by Elias (1937). The method is to define particular morphologic units and measure the frequency of these within a certain unit length. The unit defined, for example, in the measurement longtitudinally of fenestrules, is the length from the top of a dissepiment to the top of the next dissepiment. The unit then includes one fenestrule and one "space," in this case the dissepiment.

Four morphologic units are used in measurements, the "aperture unit," "fenestrule unit," "branch or midrib unit," and "node unit." By definition, each unit includes the particular morphologic feature and adjoining space (termed interspace) extending to the margin of the next such morphologic feature.

ACKNOWLEDGMENTS

I wish to express appreciation to Dr. Raymond C. Moore, under whose direction this research was carried out, for his guidance and stimulating discussions; and to Dr. John C. Frye, former Executive Director of the Kansas Geological Survey for approval of financial assistance by the Survey.

SYSTEMATIC PALEONTOLOGY

Family ACANTHOCLADIIDAE Zittel 1880

Genus PENNIRETEPORA d'Orbigny 1849

Penniretepora D'ORBIGNY, 1849, Rev. Mag. Zool. (2), v. 1, p. 501.

Type species *Retepora pluma* Phillips, 1836

PENNIRETEPORA CURVULA Richards, n. sp.

Text-fig. A—1–3

The zoarium is pinnate and up to 6 mm. long; the midrib is 0.28 to 0.52 mm. wide, with an average of 0.42 mm. The pinnae (lateral branches from midrib) measure 0.24 to 0.40 mm. wide and average 0.33 mm., they measure 18 per cm. at a 60° angle with midrib. In alternating position on opposite sides of the midrib at point of convex curvature of midrib. Apertures small, round, 0.6 mm. in diameter, 15 occurring in 5 mm., one located at upper part of base of pinnae with two between. Two ranges on midrib and pinnae. Peristome a low well-developed ridge elevating and enclosing completely each zooecial aperature. Reverse finely granulose with well-developed coarse longitudinal striae. Obverse with a prominent sharp, sinuous mesial carina, continuous with that of the pinnae. Reverse convex, obverse flattened convex. Internally zooecia elongate, rectangular in two ranges. Two cells between each pinna. Interzooecial walls thin, with remnants of hemisepta along wall in center of zooecia.

Repository.—Paleontology Museum, Univ. Kansas, Nos. 11,181B1 (holotype), 11,181B3 (hypodigm); Howard formation, Cen. N. line sec. 27, T. 11 S, R. 15 E., West Topeka brick plant, Shawnee County, Kansas.

Range.—Early Virgilian, Shawnee group. Moderately common.

Discussion.—The single prominent, sinuous keel is diagnostic. Differs chiefly from

Penniretepora flexuosa Moore in having smaller, more abundant apertures and in having more pinnae per unit length.

PENNIRETEPORA FLEXISTRIATA Richards, n. sp.
Text-fig. A—7,8

Zoarium pinnate, up to 7 mm. long in fragments; midrib 0.23 to 0.58 mm. wide, average 0.31 mm., adults average 0.50 mm. Pinnae subalternating, 0.14 to 0.32 mm. wide, average 0.21 mm., averaging 0.25 mm. for adults; 22 occur in 1 cm., forming an angle of 70° with midrib. Apertures elongate, 0.07 mm. wide by 0.12 mm. long, 14 in 5 mm. arranged one at the base of each pinna and one between in two ranges on midrib and pinnae. Peristome a low pronounced ridge, somewhat weakened at the distal ends. Reverse surface with coarse, longitudinal, granulose striae. Obverse face covered with wavy discontinuous striae that tend to swirl around apertures, more pronounced and approaching a median carina at the center. Both sides convex, the obverve somewhat flattened. Internally zooecia in the midrib arranged in one row; elongate, triangular in shape with the apex pointing inward, two complete cells occur between pinnae on the same side. Pinnae zooecia somewhat less elongate but arranged in similar manner.

Repository.—Paleontology Museum, Univ. Kansas, Nos. 11,174B2 (holotype), 11,174B3, 11,174B4 (hypodigms); Wreford formation (Three Mile member), NW¼, SW¼, sec. 1, T. 11 S., R. 10 E., Riley County, Kansas.

Range.—Abundant in formations ranging from early Virgilian to late Wolfcampian in age.

Discussion.—Discontinuous, wavy striae on the obverse surface are diagnostic of the species. The variation in zoarium size in this species is greater than in any other species I have observed or noted in the literature. This variation is probably the result of a mixture of mature and immature zoaria. The possibility can not be precluded, however, that the end members represent distinct subspecies that were coexistent. The result of this intermingling of subspecies is a hybrid population of great variety, as indicated by the extreme range in zoaria size variation (Sylvester-Bradley, 1951). Immature specimens resemble closely *Penniretepora bellula* Ulrich except for the greater number of pinnae and apertures per unit length and lack of any nodes. Internally they are identical. *P. flexuosa* Ulrich has fewer pinnae, apertures, reverse pores and obverse tubercles.

Although the midrib and pinnae widths vary between juvenile and adult, a continuous series is present and they are the same internally. For these reasons I consider that they represent a complete age group of a single population.

PENNIRETEPORA NODOCARINATA Richards, n. sp.
Text-fig. A—9,10

Zoarium pinnate, up to 6 mm. long; midrib sinuous, 0.33 to 0.45 mm. wide, average 0.38 mm. Pinnae 0.30 to 0.45 mm. wide, average 0.35 mm. at base, 17 in 1 cm., form-

EXPLANATION OF TEXT-FIG A

All figures ×10

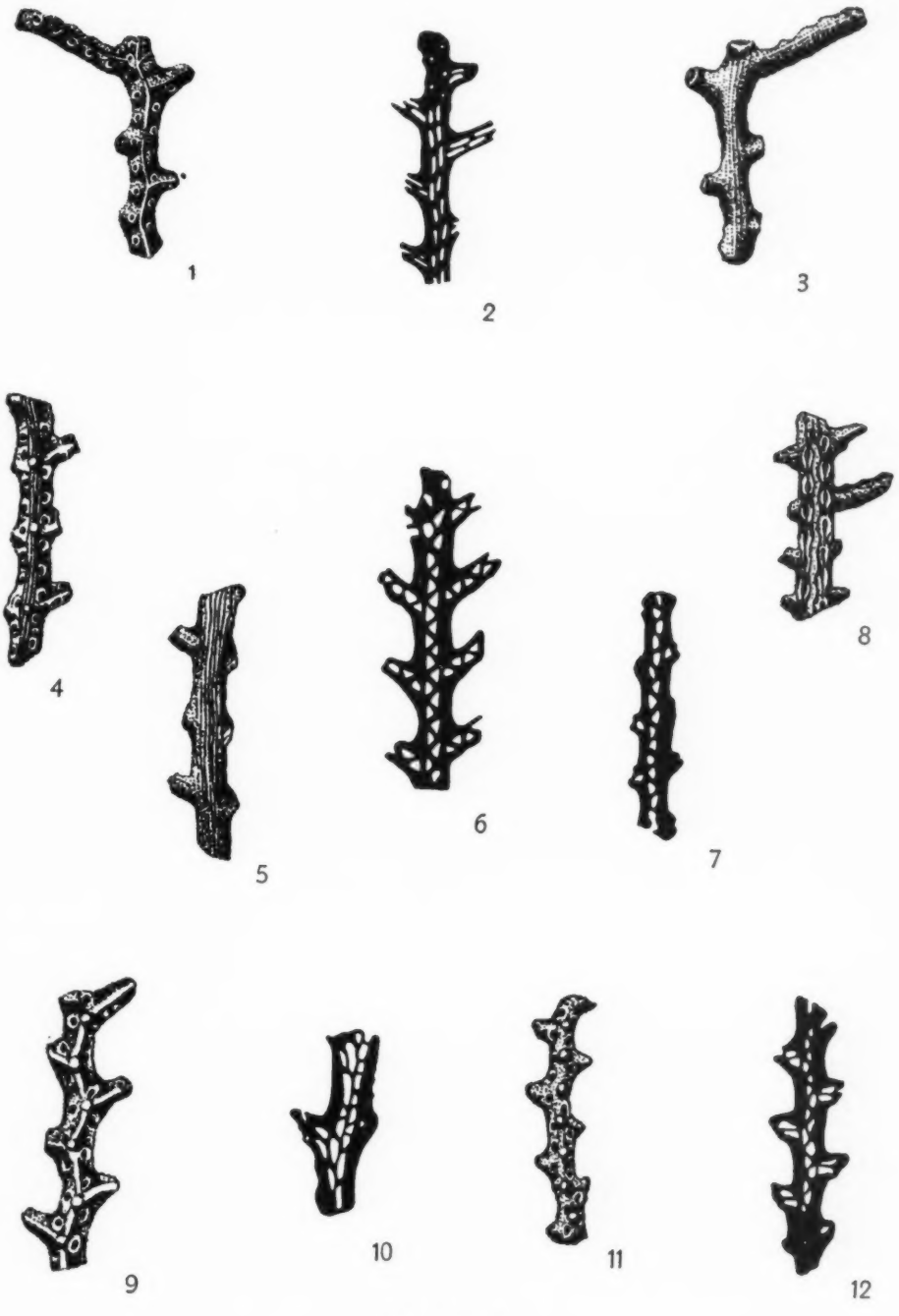
1–3—Penniretepora curvula Richards, n. sp. *1*, (K.U. No. 11,181B1), holotype, obverse face, showing diagnostic keel and well developed peristomes; *3*, holotype, reverse face, showing longitudinal striae; *2*, (K.U. No. 11,181B3), internal section, showing elongate, rectangular zooecia.

4–6—Penniretepora nodolineata Richards, n. sp. *4*, (K.U. No. 11,188B2), holotype, obverse face, showing abundant apertures, and trilineate carina with nodes; *5*, holotype, reverse face, showing granular striae. *6*, (K.U. No. 11,217B1), internal section, zooecia triangular, in one row.

7,8—Penniretepora flexistriata Richards, n. sp. *8*, (K.U. No. 11,174B2), holotype, obverse face with discontinuous, wavy striae; *7*, (K.U. No. 11,174B3), internal structure, showing triangular shaped zooecia in a single row.

9,10—Penniretepora nodocarinata Richards, n. sp. *9*, (K.U. No. 11,180B0), holotype, obverse face showing sinuous carina holding a node at each bend; *10*, (K.U. No. 6,643B1), internal structure showing rectangular zooecia in two rows.

11,12—Penniretepora pustulosa (Moore) *kansasensis* Richards, n. subsp. *11*, (*K.U.* No. 11,178B1), holotype, with low carina containing nodes, and inflated zooecial apertures; *12*, (K.U. No. 11,187B1), internal structure, showing rounded triangular zooecia in one row.



TEXT-FIG. A

ing an angle of 60° with midrib, alternating in position, one occurring at each bend of the midrib. Apertures elongate, 0.07 mm. wide by 0.09 mm. long, 13 in 5 mm., arranged one at top of base of each pinnae, two between. Two ranges on midrib and pinnae. Peristome a well-developed enclosing ridge, somewhat weakened at distal ends. Reverse face granulostriate, obverse with a prominent, sinuous median carina continuous with pinnae carina. Sharp nodes arranged on carina, one opposite each pinna at bend, 12 in 5 mm. Internally zooecia rectangular, elongate in two ranges, two between each pinna. Hemisepta well preserved in thin sections studied.

Repository.—Paleontology Museum, Univ. Kansas, Nos. 11,180B0 (holotype), 11,180B1, 1,294B1, 6,643B1 (hypodigms); Brownville formation, NW¼, sec. 27, T. 16 S., R. 12 E., north of Admire, Lyon County, Kansas.

Range.—Early Wolfcampian, Admire group. Uncommon.

Discussion.—The sinuous carina with nodes at each bend is characteristic. This species is identical to *Pennniretepora curvula* but has nodes on the carina and large zooecial aperatures.

PENNIRETEPORA NODOLINEATA
Richards, n. sp.
Text-fig. A—4–6

Zoarium pinnate, up to 1 cm. long; midribs 0.42 to 0.58 mm. wide, average 0.49 mm. Pinnae 0.33 to 0.48 mm. wide, average 0.38 mm., 18 in 1 cm. forming a 70° angle with the midrib. Arranged about one-half the width of the pinnae out of opposition. Apertures somewhat elongate, being 0.07 mm. wide and 0.09 mm. long, occurring 15 in 5 mm. One aperture occurs at the base of each pinna with two between in two ranges on midrib and pinnae. Peristome a thin, well-defined rim somewhat weaker at lower end of zooecial aperature. Reverse flattened convex, covered with granules arranged in well-defined longitudinal rows. Obverse characterized by presence of a distinctly trilineate, rounded median carina of which the central rib is the strongest. Pointed nodes occur on this ridge at intervals of about 0.09 mm. Apertural face strongly granulose, flattened convex. Internally zooecia rounded-triangular in outline, in one range. Interzooecial wall thin. Two zooecia between each pinna.

Repository.—Paleontology Museum, Univ. Kansas, Nos. 11,188B2 (holotype), 11,188B3, 11,217B1 (paratypes); Kanwaka formation (Stull member), NE¼, NE¼, sec. 10, T. 18 S., R. 16 E., Melvern, Osage County, Kansas.

Range.—Early Virgilian, Shawnee group. Uncommon. Description based on three well preserved specimens.

Discussion.—The trilineate carina, presence of nodes and abundant apertures are characteristic of this species. Very similar in all measurements to *Pennniretepora trillineata texana* Moore but with nodes on the carina. The species has 15 aperatures in 5 mm. in contrast to 7 in the species *P. paucanoda* Moore.

PENNIRETEPORA PUSTULOSA (Moore)
KANSASENSIS Richards, n. subsp.
Text-fig. A—11,12

Zoarium pinnate, 4 mm. long; midrib 0.31 to 0.46 mm. wide, average 0.37 mm., somewhat sinuous. Pinnae 0.24 to 0.34 mm. wide, average 0.30 mm., 18 in 1 cm., alternating in position and at an angle of 60° to the midrib. Apertures rounded to slightly elongate 0.07 by 0.10 mm., 17 in 5 mm., arranged one opposite the upper half of each pinna and two in the space between. Two ranges of apertures on midrib and pinnae. Peristome a low strong ridge. Reverse face with fine longitudinal granulose striations. Obverse with a sinuous median carina, low and rounded, bearing short blunt nodes, eight in 5 mm. Both faces flattened convex. Internally zooecia rounded, triangular in shape, in one range. Two zooecia between pinnae with interzooecial walls thin and irregular.

Repository.—Paleontology Museum, Univ. Kansas, Nos. 11,178B1 (holotype), 11,187B1, 11,178B2, 11,179B1, 6,077B3; (hypodigms); Oread formation, Toronto member, SW¼, NW¼, sec. 27, T. 14 S., R. 20 E., 1 mile north of Baldwin, Douglas County, Kansas.

Range.—Early Virgilian to middle Wolfcampian, Shawnee group to Council Grove group. Common in early Virgilian formations but less abundant in beds of Wolfcampian age.

Discussion.—Sinuous carina with nodes and inflated zooecial openings are characteristic of the species. The occurrence of seven instead of 14 apertures in 5 mm. distinguishes this subspecies from *Pennniretepora pustulosa*. *P. bellula* is more robust, has two apertures on the midrib between pinnae and lacks a keel.

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JOURNAL OF PALEONTOLOGY, V. 33, NO. 6, P. 1120–1124, NOVEMBER, 1959

REVIEWS

LOWER TERTIARY BIOSTRATIGRAPHY OF THE CALIFORNIA COAST RANGES, by V. Standish Mallory, Am. Assoc. Petroleum Geologists, Tulsa, Oklahoma, 416 p., 7 figs., 42 pls., 19 tables, 1959.

Mallory's book represents a tremendous task in collecting and cataloguing Eocene and Paleocene Foraminifera of California. From this work a stratigraphic subdivision based on foraminiferal zones and stages is proposed. A companion work titled "Miocene Stratigraphy of California" was published by R. M. Kleinpell in 1938, and Mallory's approach to biostratigraphic problems is essentially that used by Kleinpell. Both books are musts for anyone working in the California Tertiary.

An excellent historical review regarding the establishing of formations, stages, and zones for the Paleocene and Eocene of California is provided. Only a few highlights may be given here.

W. M. Gabb (1864) referred strata now known to be Eocene, to the Cretaceous. He later (1869) revised his Division "B" and named it the Tejon group, but continued to regard it as Cretaceous. T. W. Stanton (1895, 1896) correctly placed Gabb's Tejon into the Eocene and divided the Tejon into upper and lower horizons. The term Martinez was applied to the lower horizon by J. D. Whitney (Gabb, 1869).

Roy E. Dickerson (1914, a, b, c, d) recorded "Martinez" fossils from the Santa Ana Mountains in the south, to north of San Francisco, and "Tejon" throughout the length of the State.

B. L. Clark (1918) described the Meganos "group." The group name rapidly lost its lithologic significance, as had the Martinez before it. Clark (1918) named the Markley formation and assigned it questionably to the San Lorenzo series of Oligocene age, and in 1938 described the Markley mollusca.

Clark (1926) recognized four major "chronologic" divisions in the lower Tertiary in California, the "Martinez," "Meganos," "Domengine," and "Tejon." None of these units was formally defined or named. In 1935 Clark proposed the "Capay stage." He and Vokes (1936) summarized five "stages" of the Paleocene and Eocene epochs.

Chronologic classifications of the lower Tertiary by microfossils were soon proposed. That of Boris Laiming (1939, 1940, 1941) is the most comprehensive. Reference to other foraminiferal papers of varying import is omitted in this review.

Between 1947 and 1952 Mallory sampled and studied numerous sections of lower Tertiary stratigraphic sequences throughout California, in order to evaluate the foraminiferal assemblages of the various subdivisions and to establish a workable zonation based on chronologically diagnostic species. Besides cataloguing what he termed Paleogene foraminiferal faunas, he drew inferences from other fossils, vertebrate as well as invertebrate, as to the geologic history, paleogeography, paleoecology, and age of the various stages and zones.

The standard chronological-biostratigraphical subdivisions now proposed by Mallory consist of five stages that are further subdivided into ten zones from oldest to youngest as follows:

Ynezian stage (Paleocene)
  Silicosigmoilina californica zone
  Bulimina excavata zone
Bulitian stage (Paleocene)
  Bulimina bradburyi zone
  Valvulineria wilcoxensis zone
Penutian stage (Eocene)
  Plectofrondicularia kerni zone
  Alabamina wilcoxensis zone
Ulatisian stage (Eocene)
  Vaginulinopsis mexicana zone
  Amphimorphina californica zone
Narizian stage (Eocene)
  Bulimina corrugata zone
  Amphimorphina jenkinsi zone

Overlying the Narizian is the Refugian stage, considered to be of Oligocene age by Mallory, who shares this opinion with Schenck and Kleinpell. The large number of species common to the Refugian stage and to the Jackson group of the Gulf Coastal Plain, however, suggests their time equivalence whether or not both are early Oligocene or late Eocene in age.

Geologic mapping and sampling were used to establish the stratigraphic sequence of the various stages and zones. While most of the stages have their type localities on the west side of the southern part of the San Joaquin Valley, the Ynezian and Bulitian stages have their type localities west of

Santa Barbara. The distance and geologic complexities between these two areas increase the possibility of error in correlation. A puzzling feature is the placing of the type sections of some zones at localities other than that where the including stage is described.

The Foraminifera designated in naming zones are not necessarily confined to a particular zone or even to a stage. It is only by overlapping of the ranges of the concomitant fossils that a zone can be recognized. Why particular zones are placed in particular stages is not clearly understood by the reviewer.

Of the species used to designate zones, *Silicicosigmoilina californica* is absent from Table 19; *Bulimina excavata* is reported as "few"; *Alabamina wilcoxensis* as "rare" and "few"; *Plectofrondicularia kerni* as "rare"; *Amphimorphina californica* as "few," as is *Amphimorphina jenkinsi*. These zonal indicators are all comparatively rare but there seems to be no possibility of finding more common species for substitutes.

The use of *Vaginulinopsis mexicana* as a zone name is unfortunate as the species in its restricted sense has not been demonstrated to occur in California. Nowhere in the tables are related forms listed as common.

According to Mallory, three miliolids from the type region of the Domengine formation are identical with Lutetian species from the Paris Basin. The Domengine appears to belong to the Ulatisian stage.

Mallory's early Paleogene faunas of California show affinities with some from the Caribbean, both Cretaceous and Paleocene. (The Lizard Springs locality in Trinidad has been shown to be Paleocene rather than Cretaceous as Cushman considered it.) *Bolivinoides stewarti* from the Bulitian is close to *B. trinitatensis*. *Bulimina arkadelphiana midwayensis*, *Loxostomum applini*, *Gyroidina aequilateralis*, *Ceratobulimina perplexa*, *Robulus midwayensis*, and others are found in the Midway group of the Gulf States. (*Ceratobulimina perplexa* is shown as occurring in the Penutian stage only.)

Many Bulitian and Penutian species are similar or identical with Midway and Wilcox faunas of the Gulf Coastal Plain and with Latin American faunas. Penutian and Ulatisian species resemble or are identical with species from the Mexican Aragon, Guayabal, and Chapapote formations. Relations between faunas of the Salt Mountain limestone of Wilcox age in Alabama and the Penutian, Ulatisian, and some lower Narizian faunas exist. Capay (apparently Ulatisian) megafossils have been compared with European Ypresian species.

Many species are common to the Ulatisian, to the Claiborne of the Gulf Coastal Plain, and to Latin America strata.

Narizian species are frequently identical with Jackson forms of the Gulf Coastal Plain although Lower Narizian faunas show some relations to species from the Claiborne of the Gulf Coast. Upper Narizian faunas as well as those from the overlying Refugian stage are closely related to those of the upper Jackson of the Gulf Coastal Plain and the lower Alazan of Mexico. Very close relations exist with the fauna of the Chira shale of Peru, which is regarded to be of late Eocene age.

The many illustrations included in the book are, on the whole, excellent. Figure 2, a geologic map of the type area of the Ynezian and Bulitian stages, would have increased value if the stage names were tied to the stratigraphic position of lithic units. The same observation applies to Figures 3, 4, and 5.

A correlation chart (Fig. 7), from Canada de Santa Anita on the south to the Vaca Valley area on the north, would have been much easier to interpret if a more detailed scale than 1,000 feet to the inch had been used. Table 3, a range chart of species recognized from the type locality of the Lodo formation, would have been improved by labelling of stages and zones. The same suggestion applies to Tables 12, 14, 15, and 16.

Tables bound in the book (1, 2, 4, 5–11, 17, 18) fail to make clear the stage or zonal occurrence of the listed Foraminifera. Table 19 gives the observed stratigraphic occurrences of species in the Paleocene and Eocene (Paleogene according to Mallory) and should prove to be a very useful tool.

Papers on Eocene Foraminifera by Graham and Classen (1955) and Israelsky (1951, 1955) have not been evaluated, although eight years have passed since the first of these appeared.

Plates 1–42 are excellent drawings of Foraminifera, prepared in the main by Miss Joan Sischo. Six plates were prepared by Mrs. G. Dallas Hanna; H. A. Boyd, Jr.,

John Browning, William Grier, Richard Cifelli, and Mrs. Bernice Y. Smith also contributed.

The register of localities is a useful and welcome addition to the book.

A valuable fifteen-page bibliography of foraminiferal literature on California precedes the plate explanations and serves to cover publications up to 1956. That unpublished theses should be included in a bibliography seems most undesirable. Hugh Smith and E. J. Wilson are credited with both their published and unpublished theses.

The apparent early appearance of *Orbulina universa* in Eocene rocks deserves checking.

Over two-thirds of the book is a systematic catalogue of the Foraminifera based on Cushman's 1940 edition, only slightly modified in following Glaessner (1945). It would be presumptuous for the reviewer to pass judgment on the systematics used by Mallory. If my count is correct, 41 species and 19 varieties are described as new. Rather full synonymies are provided for the various species, and numerous occurrences are noted.

In the explanation of Plate 2 no names are given for Figures 16a,b and 17a,b. New species and varieties are not indicated as such on plate explanations.

There is no question that this book fills a long-felt need. It marks both a scientific and practical advance in the biostratigraphy of the California Tertiary. How this work will stand the test of use, and to what extent it will supersede Boris Laiming's pioneer effort of about 20 years ago, must await the passage of time.

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INTRODUCTION TO THE STUDY OF CRETACEOUS OSTRACODA, by Henry V. Howe and Anna Laura Laurencich. Louisiana State University Press, Baton Rouge 3, Louisiana, 540 p., 1,667 fig., October 26, 1958. $6\frac{1}{8} \times 9\frac{1}{4}$, buckram bound, $7.50.

Ostracodes are bivalve crustaceans which have been studied for at least 200 years. Their comparatively large size, better preservation, and easy identification have increased their usefulness in petroleum stratigraphy and paleoecology. There are about 5,000 titles that deal exclusively with these microfossils, and about 30,000 specific names have been applied to them. Their fossil remains range in time from Paleozoic to Recent. In spite of this abundant literature, there is not a single textbook on the subject that gives the distinguishing characters of ostracodes even at generic and supergeneric level. All this information is widely scattered over hundreds of periodicals written in at least a dozen languages and published in almost every country. There is no universal agreement on the usage of taxonomic nomenclature. Zoologists have based their classification on soft parts and paleontologists have erected their own classification based on the finer features of the carapace. To make order of this chaotic situation, a committee of ostracode experts has undertaken to find, digest, and decipher this information for the Treatise of Invertebrate Paleontology.

The present volume deals exclusively with Cretaceous ostracodes. The earliest papers on Cretaceous ostracodes date back to more than 120 years and most of the early volumes are inaccessible. A modern workable classification was not used by students of fossil forms until after Sars (1866) and Müller (1894) made their classic revision of living ostracodes. The ostracode classification has undergone drastic revisions in the past 20 years. Due to poor optical equipment, the pioneer students of ostracodes were able to study only the superficial ornamentation. Very rarely were the details of hingement either described or illustrated. Only generalized descriptions of superficial ornamentation and mere caricatures of the valves appear in most of the early papers. However, the classification in current use is based mainly on fine features of the carapace, thanks to the modern high-power microscopes. This situation makes it necessary that periodically a clear objective summary and analysis of the existing data be made. In the case of Cretaceous ostracodes, before publication of the present volume, such a summary dates back to 1890 (Jones & Hinde).

This present volume summarizes information contained in 167 papers and books in which 942 species of ostracodes have been reported from the Cretaceous of the world. These species are distributed among 134 genera, which are here redescribed and re-

figured. This volume is an attempt to place in the hands of Cretaceous ostracode workers an up-to-date handy reference presented in a clear, concise, and convenient manner. The volume is complete to the end of 1956 and some pertinent references with 1957 dates are also included.

This work, although not an exhaustive monograph, is more than an index and bibliography of species, for the authors have given a brief analysis and synonymy of each species together with one or more figures showing the diagnostic features of the carapace. In most cases, the illustrations were redrawn from the original figures, but where comparative material was available, the illustrations are from topotype material or from figures by modern authors who had access to either the original types or the topotype material. The authors have evaluated all the species, and in instances where no comparative material was available, it is so indicated in the text. Drs. Howe and Laurencich have given brief diagnosis of each genus, its relationship to higher taxonomic units like families and subfamilies, type species, and geologic range. In cases of genera described by recent Russian authors, due to lack of prompt translation facilities, no detailed description of the generic characters is given, but the type species of each genus is amply illustrated to facilitate usage of these new generic and supergeneric categories. Each species is alphabetized under the generic name to which it currently belongs and is cross-indexed under the generic name to which it was originally assigned. The authors also give the stratigraphic horizon of each species (whenever known) together with its size and distribution. Drs. Howe and Laurencich have described four new genera: *Kalyptovalva* (Cytherideinae), *Kikliocythere* (Brachycytherinae), *Netrocytheridea* (Cytherideinae), and *Phacorhabdotus* (Trachyleberidinae), and have also emended subfamily Eucytherinae.

There is an excellent chapter on hingement which sets out in detail the manner in which the articulation of the valves is accomplished in ostracodes. Sixteen different types of hingements (Adont, Prionodont, Lopodont, Amphidont, Paramphidont, Hemiamphidont, Holamphidont, Shizodont and Gongylodont) that apply primarily to the superfamily Cytheracea are adequately described and illustrated. A section of the book is devoted to the muscle scars and marginal areas.

All students of ostracodes, both Recent and fossil, should find this handy reference an essential addition to their research library since this work is an important revision of ostracode taxonomy. Petroleum geologists and economic paleontologists will find the information summarized in this book most useful in paleontologic zonation and stratigraphic paleontology. Excellent line drawings in the text will be of great use to both beginning and advance students of micropaleontology.

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FORAMINIFERA OF THE ORINOCO-TRINIDAD-PARIA SHELF, Reports of the Orinoco Shelf Expedition, Volume IV, by C. W. Drooger and J. P. H. Kaasschieter (1958, in English). 108 p., 4 text-figs., 5 pls., and 41 maps. Both paperbound text, 7×10.25 inches, and separate folded maps, 9.4×21 inches, inserted in pockets of folding cardboard jacket. North-Holland Publishing Company, P. O. Box 103, Amsterdam. Price, 22.50 guilders.

Lack of understanding of the distribution, ecology, and phylogeny of modern Foraminifera has long hampered the geologist in his interpretation and correlation of Mesozoic-Cenozoic deposits. This void in our knowledge is especially sensed when we are unable to read properly the voluminous pages of earth history revealed in thousands of wells drilled in America, Europe, and Asia. Every contribution to the study of modern sediments and Recent Foraminifera

helps to shape our key for unlocking the past, and this report will be welcomed by students of paleoecology and those who are interested in environments of deposition.

Drooger and Kaasschieter have studied the faunal content of some 150 samples of surface sediment taken by grab and core samples during a marine survey from the end of March to early May, 1953. Only the top part of core samples was included in their investigations. The microscopic studies were conducted in the Paleontological Department of the State University of Utrecht from January, 1955, through April, 1957. The object of this investigation was "to determine the species and to examine the possible connection of their occurrence with environmental factors, for the purpose of obtaining a basis for ecological interpretation of fossil associations."

This report on the microfauna of the Orinoco-Trinidad-Paria shelves is part of the results of a much wider investigation into the surface sediments of the Orinoco delta and adjoining regions. The research was supported by the Institute for Marine Geology of the University of Groningen and the Bataafsche Petroleum Maatschappÿ H. V. at The Hague. The first paper of the series was published by Tj. van Andel, H. Postma, and collaborators in 1954 on the sediment and fauna of the Gulf of Paria. The microfauna of the Gulf was described in this publication by C. Kruit and A. J. Key.

In *Foraminifera of the Orinoco-Trinidad-Paria Shelf*, the first 23 pages are devoted to determination procedure (method of species identification), method of determining and representing frequencies of microfossils in the samples, conclusions as to the rate of sedimentation, and a discussion of several zones or areas of the Shelf which are characterized by high frequencies of certain foraminiferal species. This section also contains ecological comparisons of the Shelf assemblages with fossil associations described from the Miocene and Pleistocene of Aruba, the Oligo-Miocene of the Agua Salada group in Venezuela, and the Miocene Tubara beds of Colombia.

The next 64 pages contain systematic descriptions of the Foraminifera with remarks on variation of plesiotypes from type species and other identification notes. Distribution data are also given for each species including maximum and minimum depths, sediment type, and salinity. A similar treatment is given the Ostracoda in the next five pages.

Foraminifera and Ostracoda are amply represented on five plates of drawings which are above the average for this type of illustration. Plate 5 is especially interesting and valuable to students of planktonic Foraminifera in that all the planktonic species identified in the report are figured at the same magnification. There is some loss of detail in the drawings of the smaller species, but these are adequately illustrated on Plate 4. Each map on which the relative frequencies of a species are contoured also bears several figures of the subject organism.

Maps 1 and 2 show sample locations and surface sediment types respectively. Maps 3 to 37 are topographic charts contoured on the relative frequencies of those benthonic species which showed some effect by environmental factors (depth, sediment type, salinity). Maps 38 to 40 show the distribution of planktonic foraminifers, and Map 41 is contoured on total Ostracoda.

The significant ecologic conclusions drawn from this report are as follows:

1. An area of silty and sandy pelite in the coastal part of the Orinoco shelf supports a predominance of forms of *Rotalia*, probably as a consequence of tolerance of this group for varying salinity.

2. A pelite area of the inner Orinoco shelf is characterized by species of *Nonionella*, *Uvigerina*, *Virgulina*, and *Cancris*. The controlling factors are probably depth and pelite.

3. A pelite area north of Trinidad-Paria supports high percentages of *Uvigerina*, *Höglundina*, and *Eponides regularis*. Fully marine conditions and the pelite evidently determine this type of association.

4. The shallow reef area east of Trinidad with coarse sediments contains an association of many *Amphistegina lessonii* and *Cibicides pseudoungerianus* varieties in its seaward part with more Miliolidae and arenaceous forms in its shoreward part.

5. The outer part of the Orinoco shelf contains a variable mixture of Pleistocene and Recent species.

6. The planktonic-benthonic ratio gradually increases in offshore direction.

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JOURNAL OF PALEONTOLOGY, V. 33, NO. 6, P. 1125–1128, 1 TEXT-FIG., NOVEMBER, 1959

PALEONTOLOGICAL NOTES

AN OCCURRENCE OF *OPHIURASTER BURRISI* MILLER

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A fossil collection made by the writer in 1953 from the upper Speiser Shale (Wolfcampian) of Kansas contains a specimen of *Derbyia cymbula* Hall & Clark on which is cemented a small but rather well-preserved ophiuroid. The extreme rarity of Permian ophiuroids makes the discovery and description of this fossil of special interest.

The specimen (Text-fig. 1) displays only the aboral surface of disc and arms, but the number and arrangement of disc plates, observable arm structure, and the size of the disc and arms show clearly that this specimen is *Ophiuraster burrisi* Miller. The writer has examined the type specimens and verified this identification. The average diameter of the somewhat distorted central disc is 5.6 mm. None of the arms is complete, and one is entirely missing. The greatest length observed among the remaining arms is 6.3 mm. The best-preserved arm has a maximum diameter of 1.3 mm. near the base, but the ossicles have been partly separated. Aboral arm shields and lateral arm shields are the only skeletal elements visible in the appendages.

The specimen was collected from the upper 3.7 feet of the Speiser Shale at a stream bank in the NE¼, NW¼, sec. 31, T. 29 S., R. 8 E., 4 miles southeast of Latham, Butler County, Kansas. Faunal associates of *Ophiuraster burrisi* in the dark gray argillaceous to limy shale at this locality are: *Derbyia*, *Chonetes*, *Dictyoclostus*, *Composita*,

TEXT-FIG. 1—*Ophiuraster burrisi* Miller. Aboral view of specimen from the upper Speiser Shale of Butler County, Kansas; ×8.

Orbiculoidea, *Aviculopecten*, fenestelloid bryozoans, and crinoid remains.

Specimens of *Ophiuraster burrisi* described by Miller (1958) are from the Americus Limestone (Wolfcampian) at the base of the Council Grove Group. The discovery of the Speiser ophiuroid in topmost strata of the Council Grove Group extends greatly the known stratigraphic range of this species. The hypotype described herein is specimen 6307 in the Indiana University Paleontologic Collection.

An additional specimen of *Ophiuraster burrisi* was collected recently in the N½, NE¼, sec. 2, T. 28 N., R. 5 E., Osage County, Oklahoma, by D. F. Merriam of the Kansas Geological Survey. The specimen is approximately the same size as that described above and displays the aboral surface. The arms are intact and well preserved but the disc is badly eroded. This specimen is from the Cottonwood Limestone Member of the Beattie Limestone (Council Grove Group).

REFERENCE

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TEXAS CRETACEOUS OPHIUROIDS

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Berry (1941) brought together descriptions of all known Texas Cretaceous ophiuroids. This included three species of the more than 20 known Cretaceous species from throughout the world (Rasmussen, 1950).

Ophiura texana (Clark), described in 1893 and 1915, came from a locality in the Weno (Lower Cretaceous) just south of Ft. Worth. *O. graysonensis* (Alexander) came from the Grayson (Upper Cretaceous) of the Ft. Worth area, and *O. travisana* Berry was erected for disassociated plates found in the Navarro (Upper Cretaceous) of Travis County. The latter species has become suspect since Rasmussen (1950) has raised some question as to Berry's (1938) method of reconstruction for other Upper Cretaceous ophiuroids.

In 1957, Mr. James Pitken who was mapping the Cretaceous in northern Ellis County south of Dallas, found an ammonite identified as *Parapuzosia*, the common upper Austin index fossil in north Texas. Cemented to one side of this ammonite were several complete specimens and isolated arms and other plates of ophiuroids. As far as can be determined these specimens are the first ophiuroids reported from the Upper Cretaceous Austin Chalk. They appear to be conspecific with *Ophiura graysonensis* (Alexander) described in 1931 from the Grayson Formation of Cenomanian age. This find extends the range of the species to the Campanian (Young, 1958).

The occurrence of the ophiuroids cemented to one side of *Parapuzosia* suggests that the ophiuroids may have moved under the dead ammonite lying on the sea bottom. The fact that the oral sides of the two ophiuroids are free and the aboral side attached to the ammonite shell suggests that the ophiuroids died in position under the ammonite and remained attached.

There are a great number of isolated plates and arm spines concentrated in small areas around the complete remains. In addition, species of typical upper Austin foraminifers including *Gümbelina*, *Globigerina*, *Globotruncana*, *Nodosaria*, *Planulina*, and *Anomalina*, are associated with the ophiuroid remains.

OPHIURA GRAYSONENSIS (Alexander)

The material here described consists of two rather complete specimens and in addition isolated arms and various plates from at least two other individuals. Oral or ventral side of specimens exposed only.

Large mouth with well developed jaw plates which meet at about 30 degrees. Triangular "teeth," between 6 and 10 in number on oral side of jaw plates. Side mouth shield plates of same size as jaw plates and meet at about same angle. Angle of convergence just slightly behind (aboral) of convergence of jaw plates, small gap between may be due to preservation. Oral shields in contact with aboral position of side mouth plates. Shields spear-like in shape, sides on adoral portion slightly concave, aboral portion rounded. As in type material (Berry, 1941), adoral portion of arms stand above shield, but unlike type, only two to three of the ventral arm plates are incorporated in the disk. Berry (1941, p. 63) records five ventral arm plates incorporated in the holotype with a 10 mm. disk. Both of the Austin specimens have a disk only 3 mm., which is probably a young growth stage. Disk composed of numerous small plates.

Ventral side of arms are comparable to the holotype. The shape of these plates is in general a truncated triangle whose curved base is aboral in position.

Tentacle pores are obliquely set, arm spines are preserved in position on one specimen, the longest spine is 2.5 mm. in length. Each lateral arm plate bears four spines, two on either side or a total of eight for a complete arm segment.

Dorsal disk plates are present in fragments around complete specimens.

Repository.—Museum of Paleontology, Southern Methodist University, 30024.

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NEW NAME FOR A VICTORIAN PELECYPOD

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In 1933, the late F. Chapman and I proposed the name *Venericardia spinulosa* (Tate) var. *dennanti* for a small carditid from the Lower Pliocene (Kalimnan) deposits of Gippsland, Victoria. Dr. N. H. Ludbrook has kindly brought to my notice that this form belongs to the genus *Glans* Megerle, 1811. Ludbrook (1955) suggested that should the species described by Tate and Basedow in 1902 as *Cardita dennanti* prove to be a *Glans*, our form would require a new name. In a paper now in the press, Ludbrook has redescribed *Cardita dennanti* Tate & Basedow as *Glans dennanti*. I therefore formally propose the new name of *Glans kelimnae* for *Venericardia spinulosa* (Tate) var. *dennanti* Chapman & Crespin, 1933.

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RHYNCHOGNATHODUS, NEW NAME FOR THE ORDOVICIAN CONODONT *RHYNCHOGNATHUS*, PREOCCUPIED

R. L. ETHINGTON
Arizona State University, Tempe

Dr. W. H. Hass has kindly drawn my attention to the fact that *Rhynchognathus* Ethington (1959, p. 286–287) is preoccupied by *Rhynchognathus* Jaekel (1929, p. 60). I therefore propose *Rhynchognathodus*, nom., subst., for *Rhynchognathus* Ethington, 1959.

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SOME FOSSIL FISH TEETH FROM TERTIARY DEPOSITS OF MAYURBHANJ, INDIA: CORRECTION

B. K. GHOSH
Indian Institute of Technology, Kharagpur, India

The following errors have been noted in the article cited (Ghosh, July 1959):

(1) P. 676, column 1, line 6 from bottom —for 42.5 mm. read 60 mm.

(2) P. 676, column 1, line 5 from bottom —for 36.5 mm. and 10.5 mm. read 45 mm. and 12.5 mm.

(3) P. 677, column 1, line 8—for 12 mm. read 4.5 mm.

(4) P. 677, column 1, line 9—for 12 mm. and 3 mm. read 6 mm. and 1 mm.

(5) P. 677, column 2, line 4—for 3 cm. read 6 cm.

MIOCENE (BURDIGALIAN) FORAMINIFERA FROM KATHIAWAR, WESTERN INDIA: CORRECTION

S. B. BHATIA
New Civil Lines, Lucknow, India

The initials of S. B. Bhatia were incorrectly given as S. R. in the article cited (Bhatia and Mohan, July 1959). The error occurred on the cover, beneath the title on page 641, and in the running head on successive pages.

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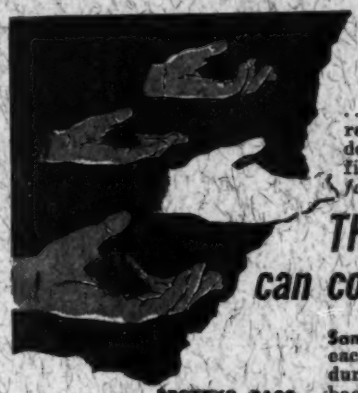

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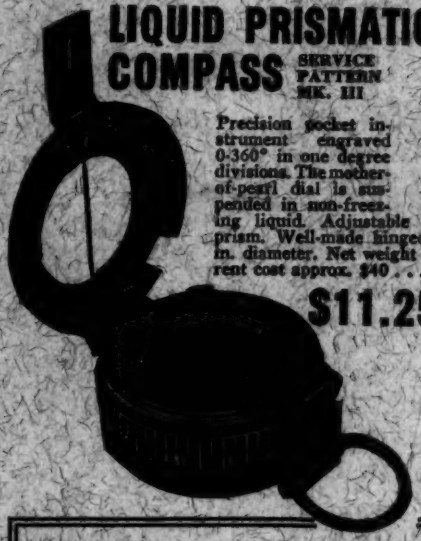

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(by E. R. WATTS)

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